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SEP 1922

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Illustrated Advertisement Page 166, Jan. 20, 1921.

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EXCAVATORS, CRANE-HAVVIES, GRABS, CONCRETE-MIXERS, SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 937
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See Advertisement Page 80. 9952

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HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING
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&c. &c. 846

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See Full Page Advt., page 58, Aug. 18.

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About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices. 8195
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Pott, Cassels & Williamson,
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See half-page Advertisement page 72, August 4.

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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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City of Cardiff Education Committee.

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DEPARTMENT OF ENGINEERING.
Head of Department:
A. W. LOVERIDGE, B.Sc. (Eng.), A.R.C.Sc.

SESSION 1922-23
(commencing on Tuesday, 3rd October, 1922).

The following COURSES have been arranged for Engineering Students:—

A Three-years' Course in Mechanical and Marine Engineering, jointly with the University College of South Wales and Monmouthshire.

A Two-years' Course for apprentices and others with facilities for practical experience in the Summer Term.

These Courses are suitable for students preparing for degrees in Engineering or for the examinations of the Engineering Societies.

Special Courses are also arranged for Marine Engineers preparing for the examinations of the Board of Trade.

For further particulars of Full-Time and Part-Time Courses, Entrance Examination, Scholarships, Fees, &c., apply to the Principal. Forms of application for admission to the Entrance Scholarship Examination, duly completed, must be received by the 16th September.

JOHN J. JACKSON, Director of Education, City Hall, Cardiff. W 68

The University of Sheffield.

SESSION 1922-23.

VICE-CHANCELLOR:
SIR HENRY HADOW, C.B.E., M.A., D.Mus.

DEPARTMENTS OF MECHANICAL, ELECTRICAL AND CIVIL ENGINEERING, METALLURGY, MINING, FUEL TECHNOLOGY AND GLASS TECHNOLOGY.

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The LECTURE COURSES commence OCTOBER 4th, 1922.

The TECHNICAL LABORATORY COURSES commence SEPTEMBER 26th, 1922.

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Correspondence Courses for Inst. Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by MR. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 9/11, TRAFFORD CHAMBERS, 32, SOUTH JOHN STREET, LIVERPOOL. 976

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TENDERS.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply of:—

1. RAILS, 41½ lbs. per yard, and fishplates.
2. LATHES, sliding, surfacing, and screw-cutting, and brass finishing.
3. CRANES, scaling, steam.
4. MACHINES, weighing platform.
5. JACKS, screw, lifting and traversing.
6. ENGINES and BOILERS for stern wheel steamer.

Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than TWO o'clock p.m. on Friday, the 8th September, 1922, for Nos. 1 and 2, and on Friday, the 15th September, 1922, for Nos. 3 to 6.
T. RYAN, Director-General. W 89

LONDON COUNTY COUNCIL.

Tenders are Invited for the SUPPLY and ERECTION of a WIRE NETTING SCREEN around the Oval at Southwark Park. Specification and form of Tender may be had on application to the CHIEF OFFICER, Parks Department, The County Hall, Westminster Bridge, S.E. 1, and are to be returned in the envelope provided for the purpose to the Clerk of the Council, at the County Hall before FOUR p.m. on 11th September, 1922. The Council does not bind itself to accept the lowest or any tender.
JAMES BIRD,
Clerk of the London County Council. W 90

MANCHESTER CORPORATION WATERWORKS.

HYDRAULIC POWER SUPPLY.

The Waterworks Committee invite

Tenders for One Electrically-driven Air Compressor.

Specification and Form of Tender may be obtained on application to the SECRETARY, Waterworks Offices, Town Hall, Manchester, on payment of Two Guineas, which sum will be returned on receipt of a *bona fide* Tender.

Extra copies of the Specification may be obtained on payment of 10s. 6d. per copy.

Any other information required respecting the work will be furnished by the WATER ENGINEER, Town Hall, Manchester.

Tenders must be delivered not later than the 9th September, 1922. W 88

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Borough Council invite

Offers for the Purchase of:—

(a) SURFACE CONDENSING PLANT by Messrs. The British Thomson-Houston Co., Ltd. Capacity 27,000 lbs. per hour.

(b) CONTRA-FLOW CONDENSING PLANT by Messrs. Richardsons, Westgarth & Co., Ltd. Capacity 45,000 lbs. per hour.

Specification and full particulars obtainable from the Engineer and Manager, Electricity Works, 85, Fulham Palace Road, W. 6.
LESLIE GORDON,
Town Clerk.
Town Hall, Hammersmith, W. 6.
21st August, 1922. W94

EAST INDIAN RAILWAY.

The Directors are prepared to receive up to Eleven o'clock a.m. on Wednesday, the 6th September proximo,

Tenders for the Supply of:—

METALS (Antimony, Brass and Copper Sheets, Rods, Wire and Tubes, and Lead and Zinc Sheets).

Copies of the Specification can be obtained at the Company's Offices on payment of £1 1s. each. This fee will not be returned.
G. B. LILLIE,
Secretary.
73-74, King William Street,
London, E.C. 4.
23rd August, 1922. W 118

COUNTY OF LONDON ELECTRIC SUPPLY CO., LTD.

BARKING POWER STATION.

The County of London Electric Supply Company, Ltd., are open to receive

Tenders for the Supply and ERECTION of STEAM TURBO-ALTERNATORS for their Barking Power Station. Specifications may be obtained by turbine manufacturers from the offices of the Company on application to the undersigned on or after August 28th and on payment of a fee of Five Guineas for the first copy and Two Guineas for every subsequent copy. Sealed Tenders marked "Tenders for Turbo-Alternators for Barking Power Station" are to be addressed to the undersigned and lodged at the Registered Office of the Company by Noon on October 18th, 1922. Sums paid for any number of copies up to three will be refunded on receipt of a *bona fide* Tender. The Company do not bind themselves to accept the lowest or any Tender.
F. C. McQUOWN,
Manager and Secretary.
The County of London Electric Supply Co., Ltd.,
Moorgate Court, Moorgate Place, E.C. 2. W 109

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

1. 46 Metre Gauge LOCOMOTIVES and SIX LOCOMOTIVE BOILERS.
2. 106 Metre Gauge WAGONS.
3. BRIDGEWORK.

Specifications and Forms of Tender will be available on Monday, 28th August, 1922, at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Locomotives," or, as the case may be, must be left with the undersigned not later than Twelve noon on Wednesday, the 4th October, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £2 for each copy of Specification No. 1, and £1 for each copy of Specifications Nos. 2 and 3.

Copies of the Drawings may be obtained at the Offices of Messrs. R. WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.
A. MUIRHEAD,
Managing Director.
91, Petty France, Westminster, S.W. 1.
24th August, 1922. W 113

LIVERPOOL CORPORATION WATERWORKS.

NEW TRUNK MAIN FROM PRESCOT: CONTRACT NO. 2.

PIPE-LAYING.

The WATER COMMITTEE of the LIVERPOOL CORPORATION are prepared to receive

Tenders from Competent Persons willing to enter into a Contract for the LAYING OF CAST-IRON PIPES of 42 in. and 40 in. internal diameter and other ancillary works, as follows, viz.:—

From the PRESCOT RESERVOIRS of the Liverpool Corporation TO RATHBONE ROAD, LIVERPOOL, in the county of Lancaster, for a distance of about 6 miles.

The Plans and Sections may be inspected, and copies of the Specification and Form of Tender obtained on and after Monday, the 28th August, 1922, at the Water Engineer's Office, Alexandra Buildings, 55, Dale Street, Liverpool, upon payment of the sum of Five Guineas, which amount will be returned upon receipt of a *bona-fide* tender.

Tenders, endorsed "Tender for Pipe-laying" are to be sent through the Post, in a sealed envelope, addressed "Chairman of the Water Committee, Town Clerk's Office, Municipal Buildings, Liverpool," so as to be delivered not later than Twelve o'clock noon, on Tuesday, the 19th September, 1922.

The Water Committee do not bind themselves to accept the lowest or any other tender.
G. HAMMOND ETHERTON,
Town Clerk.
Municipal Buildings,
Liverpool,
26th August, 1922. W 101

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place,
Strand,
London, W.C. 2.

SPECIFICATION No. 283—COAL HANDLING PLANT FOR MORWELL POWER STATION AND BRIQUETING WORKS.

CHARGE:—
£2 2s. for the first two copies of Tender Form, Conditions of Contract, Specification and Drawings complete. These charges will be returned on receipt of a *bona fide* Tender. A third copy and any further copies will be supplied for the sum of £1 1s. each.

PRELIMINARY DEPOSIT.
A Preliminary Deposit of £50 is to be lodged with Tender.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 18th December, 1922.
R. LIDDELOW,
Secretary.
State Electricity Commission of Victoria,
Melbourne,
Victoria,
Australia. W 96

APPOINTMENTS OPEN.

THE YORKSHIRE ELECTRIC POWER COMPANY.

The Yorkshire Electric Power Company invite

Applications for an Assistant in the Sales Department. Applicants must be competent to prepare quotations and estimates for electricity supply and installation work. Sound technical training and practical engineering experience essential.

Commencing salary £400 per annum.

Applications marked "ORG," to W. B. WOODHOUSE, 36, Park Place, Leeds. W 104

Engineer.—Wanted, by a London Engineering Concern, with Works in the provinces, an ENGINEER for a position of responsibility in the Works. Applicants must have had first-class practical experience in electrical engineering as applied to the manufacture of large types of electrical apparatus, backed up by sound technical knowledge. The position offers scope for the right man, and only those who are really qualified to fill the vacancy should apply. Applications, which will be treated in confidence, should state age, experience and qualifications, positions held, and salary required.—Address, W 117, Offices of ENGINEERING.

COUNTY BOROUGH OF BRIGHTON.

WATERWORKS ENGINEER.

The Council invite

Applications for the Appointment of WATERWORKS ENGINEER.

Applicants must be duly qualified Civil Engineers not more than 40 years of age and must have had experience in the management of a Waterworks Undertaking supplied by pumping from deep wells.

The salary will be £900 per annum increasing by four annual increments of £50 to £1100 per annum.

Particulars of the Qualifications, Duties and Conditions of Appointment can be obtained from the undersigned.

Applications must be made on the official form and must reach me before 12 noon on the 15th day of September, 1922.

Canvassing either directly or indirectly will be a disqualification.
HUGO TALBOT,
Town Clerk.
Town Hall, Brighton.
12th August, 1922. W 43

Young and Fully Qualified MECHANICAL ENGINEER REQUIRED to control Technical Stores and assist Chief Engineer of large plant in Central Africa. Sound, practical and theoretical experience and good education essential. Knowledge of French an advantage; experience, salary expected and age, which should not exceed 30 or 32.—Address W 78, Offices of ENGINEERING.

Engineers and Technical Assistants WANTED, with good theoretical and practical training in electrical engineering. Applications, with copies of three testimonials and full particulars of training, experience, foreign languages (if any), age and salary expected, should be sent to CHIEF ENGINEER, Marconi's Wireless Telegraph Co., Ltd., Marconi House, Strand, London, W.C. 2. W 80

Engineer Assistants for Tea Gardens in Assam. Well educated young men who have served full apprenticeship in engineering shops, with knowledge of internal combustion engines.—Write, with full particulars, to BOX B.P.E., c/o DAVIES & Co., 95, Bishopsgate, E.C. 3. W 110

Turbine Designer.—Wanted, by a large London Firm with Works in the Provinces, an Experienced and Competent TURBINE DESIGNER. Applicants must have had University or equal training, with actual experience in the design of modern Turbines. None but fully qualified men need apply. Applications (which will be treated in confidence) should state age, experience, qualifications, positions already held, and salary required.—Address, W 79, Offices of ENGINEERING.

A Thoroughly trained Mechanical Engineer. The above is REQUIRED to fill the post of Vice-Principal in an Educational Workshop in India. The concern, though State-owned, is run on thoroughly commercial lines, undertaking both manufacturing and jobbing work. Apprentices will be given half a day shop work and half a day schooling. 500 to 600 boys will undergo training at once. The applicant will be required to have a thoroughly practical knowledge of all work in a mechanical workshop so as to be able to overlook and guide the instructions given. Salary offered will be £650 rising to £800, with chances of further promotion depending upon the success of the undertaking. The incumbent will be expected to pass a higher grade in Urdu within two years of his arrival in India. He will be provided with house allowance or free quarters. Second class return passage will be paid in case of his services being dispensed with in or before Three years.—Applications, in writing, with copies of testimonials to be sent to W 105, Offices of ENGINEERING.

Wanted, Experienced DESIGNER and ESTIMATOR, accustomed to actual design and manufacture of Rapid Water Filtration Plant. Applications treated confidentially. State experience, present position, and salary required. Engagement for one year, but probably permanent for suitable man.—Write, BOX No. 601, Advertising Offices, 84, Queen Victoria Street, London, E.C. 4. W 83

Wanted, General Manager for large Motor Car Works, on Salary and Commission. Only those with previous experience need apply. Must be used to the latest methods of production, tools, jig designing, costing, &c., able to control in every way the output of cars at the lowest possible price.—Apply, in confidence, BOX No. 2255, care of J. C. FRANCIS & Co., 131, Fleet Street, E.C. 4. W 67

Draughtsman Required. North-East Coast. Must be thoroughly competent on all classes of structural work and bridge work. Age 30 to 40. Full particulars, stating salary required.—Address, U 718, Offices of ENGINEERING.

Draughtsman Required by large Engineering concern for extra high pressure switchgear. Must be neat, quick, accurate, and fully conversant with modern switchgear arrangements for voltages of over 25,000. State age, training, experience and salary required.—Address, W 53, Offices of ENGINEERING.

Draughtsman Required by large Engineering concern, fully experienced in the detailing of machine parts. Must be neat, quick and accurate. State age, training, experience and salary required.—Address, W 54, Offices of ENGINEERING.

Wanted, Draughtsman for large works in Midlands, young and energetic, with experience in plant design and layout.—Address, W 76, Offices of ENGINEERING.

Wanted, One Steam Crane DRAUGHTSMAN; also One Winch and Windlass DRAUGHTSMAN; each to be thoroughly experienced; only first-class men need apply. State age, experience and salary required and when at liberty.—JOHN H. WILSON & CO., Ltd., Dock Road, Birkenhead. W 102

THE DESIGN OF SHALLOW-DRAUGHT RIVER STEAMERS.

THE design of steamers of limited draught for use on very shallow rivers demands the exercise of very great care to ensure that the scantlings of all parts are of sufficient strength, yet not too heavy, and also a wise selection of alternatives so that al solute essentials only are included in the final design. In cases where large fleets are concerned it is not unusual to find that succeeding boats of a class have a continuously increasing light draught. This increase may be too small to attract attention in the earlier vessels, but it finally becomes too pronounced to escape notice, and an examination of alterations made in a series of similar vessels will reveal the fact that there has been an increase of weight due to additional requirements every time a new vessel was ordered. An actual example of this may be taken by comparing two vessels of the same size and power, being the first and last of a series of ten built in twelve years; it was found that the most recent boat was 2 in. deeper than the first vessel under the same light-draught conditions.

An examination showed the following list of "improvements," which had been introduced at various times, each one adding more or less weight to the original design and consequently shutting out a corresponding amount of cargo:—

(1) Sponsons had been lengthened and four vertical fenders fitted on each side instead of two. Each fender had of course the usual stiffening behind it and tie-beams across under the upper deck. (2) Upper deck and roof carried out over sponsons in later vessels, which was not fitted in first vessel. (3) Extra anchors and cables fitted. (4) Extra cabins fitted. (5) Donkey boiler and pump fitted. (6) Two electric engines instead of one. (7) Two fan engines instead of one. (8) Weir's independent feed pump and float tank instead of main feed pumps on the main engine. (9) Increased quantity of spare parts for paddle wheels. (10) Increased thickness of bow plating. (11) Increased thickness of upper deck planking.

It must be admitted that the last ship is superior in many ways to the original vessel, but, as any boat is built primarily to carry cargo, it follows that any improvement which reduces the profit-earning weight that can be carried must be of great value before its incorporation in the design can be justified. For instance, the increased width of the upper deck was justified by the larger number of passengers which could be carried and was retained, but the longer sponson and extra vertical fenders were found to be unnecessary in practice, and the short sponson was reverted to with a considerable saving in weight.

In very small vessels another serious increase in light draught is caused by the accumulation in the vessel itself of such things as paint drums, both full and empty, stores of various kinds, supplies of bolts and nuts, engine-room tools and materials, and similar details. Mates, engineers and stewards all thoughtlessly combine to load the vessel down with their individual collection of probable and improbable requirements, and all equally and indignantly resent any attempt to reduce their hoards. The engine-room staff especially are very guilty in this respect, not due to any psychological defect in the average engineer's intellect, but simply because most of the articles which an engineer gathers round him are so very heavy. It is quite a common sight to see a shallow-draught stern-wheeler, in which every pound has been saved in the original design as regards the actual scantlings of the hull, fitted with a heavy wooden vice bench and vice in the engine-room, an anvil and block, a rivet forge, and a collection of tools that any man might be proud of. No doubt the engineer of such a craft would say that he was prepared for all emergencies, but he would serve his employer better if he left his anvil and forge ashore and heated his iron in the boiler furnace and hammered it on the nearest mooring bollard.

Spare gear is another point on which some people run riot without sufficient consideration, with the result that not only is the engine-room packed with brasses and bolts, but the precious deck space is lumbered up with rudders, paddle floats, anchors, &c., until tons of valuable freight-paying cargo must be shut out. It is obvious therefore that not only must weight be kept down to a minimum in the original design of the vessel, but during the whole life of the boat care must be taken to prevent gradual accumulation in any department of material of doubtful usefulness. No hard-and-fast rule can be laid down, as so much depends on the circumstances under which the vessel plies, the accessibility of the nearest repair shop, and the trouble likely to be met with between stations.

Just as it is the engineer who, in his desire to be prepared for trouble, is most likely to offend by unconsciously accumulating unnecessary weight in stores and tools, so it is he also who, in his desire to avoid trouble or breakdown as far as possible, is most likely to add to the initial weight of the machinery by specifying duplicates and alternatives out of all reason or even possibility. It is therefore very necessary for the engineer responsible for the specification of the machinery for a shallow-draught vessel to remember, in a ship of this kind, that not only is it usually absolutely impossible to get all he would like in his engine-room, but that it is very often necessary to considerably reduce what were originally minimum requirements. For instance, if an extra large boiler is to be fitted so that the vessel may burn wood fuel, then it is quite unnecessary to fit forced draught for the purpose of burning coal. Forced draught is too violent for wood fuel, and the boiler would be big enough for coal without forcing. Again, if the ship is plying in fresh water and using cheap fuel, it is needless weight and expense to fit a surface-condenser and corresponding pumps. If a non-condensing engine be fitted, with the exhaust taken into the funnel, the boiler can be made smaller and lighter owing to the increased draught in the furnace. Some engineers, however, think that these arrangements are old-fashioned and hopelessly out of date in the twentieth century, but a little careful thought will prove that under certain conditions these old-fashioned ideas have still much to recommend them.

Regarding boilers the average engineer becomes conservative, and instead of specifying the modern water-tube boiler, he continues to fit the old-fashioned return-tube boiler or the locomotive type. This is an item in which a very great saving in weight can be made not only in the boiler itself, but also in the water it contains, and the hull stiffening required to support it. It is advisable, however, to fit an extra large steam drum in all water-tube boilers fitted on paddle and stern wheel steamers, as it is found that the large slow-running cylinders cause a pulsation in the flow of steam in the pipe, which in turn causes priming. A large steam drum holds more water, and of course this is a slight disadvantage from the weight point of view, but where the boiler is to be in charge of a native driver it provides a larger margin of fluctuation in the water-supply and does not demand such constant attention. Another advantage of the large steam drum in the 3-drum type of boiler is that it permits of new tubes being fitted from the upper drum, which is a great advantage indeed when repairs have to be carried out abroad without many of the facilities obtainable at home.

Steam steering gear is another source of waste if fitted to the smaller vessels, unless the course of the river is too tortuous to permit of hand-steering, but in very many cases steam steering engines are fitted only to create an appearance of being very up-to-date and are quite unnecessary.

Anchors and cables are very heavy, and great care should therefore be taken to ensure that the specification of these items does not include any superfluity. Some river steamers never use their anchors, while others require them ten or a dozen times a day, so that each case must be carefully considered, and here again no hard-and-fast rule can be made.

The question of speed required for any proposed vessel is a very difficult one, but is extremely important. It is difficult to estimate because of the varying nature of the voyages performed and calling stations visited. It is not unusual to call for a much higher speed than will ever be required, and this greatly increases the size and cost of the whole vessel. Where a moderate speed is sufficient it is very extravagant to specify for an extra mile or two, because, whereas the slow boat might have been a practical proposition with a fair chance of success, the faster vessel would be a freak boat fitted with very expensive machinery, costly to build, run and repair. This question of speed is very important even within the limits to be obtained with ordinary machinery. There is no benefit in fitting a large powerful engine with forced draught and all necessary pumps and connections only to run the outfit at about half-power or less, as is often the case—the forced-draught outfit of no use and everything else far too big for its job, occupying space and weight which might be more profitably employed and costing originally double the money that need have been spent on it. A very usual and successful speed for ordinary small river boats is 10 m.p.h. As a rule this speed can be obtained with ordinary simple machinery without undue reduction of weight or very high revolutions, but as the size of the vessel increases higher speeds may be obtained up to 13 miles in the larger boats without unduly cutting weight in any part.

The golden rule, as far as the machinery is concerned, is to eliminate as much as possible and have things as simple and straightforward as they can be made. In seagoing vessels all means are employed to reduce the fuel consumption, especially on long voyages. On river boats, however, this fuel economy is not usually so important as light draught and simplicity, and consequently it is quite permissible to fit the less economical engine in favour of low first cost, light weight and simplicity.

In discussing these heavy weights it must not be forgotten that much weight can also be saved in small details such as mooring bollards, fairleads, stanchions, valves, hand-wheels, beds, chairs, coat-hooks, locks, etc. Everything should be of the lightest pattern consistent with sufficient strength, and it should always be remembered by all concerned that the ultimate success of the steamer lies in the thoroughness with which unnecessary weights are omitted in the design. One point, however, must not be lost sight of by the designer of the ship, and that is that, when the vessel goes out to her destination, is re-erected, and launched, there are always certain weights added by the owners over and above what have been originally specified, and much trouble and correspondence are sometimes caused by this habit. If the builders would safeguard themselves, they should insist when the contract is made that the owners will provide a complete list of all weights placed on board the vessel, no matter by whom supplied.

The foregoing remarks all refer to the increase of carrying capacity by the reduction of the weight of hull and machinery, but the same effect can be obtained by increasing the block coefficient. In this connection, however, it is necessary to proceed cautiously, especially in very bluff paddle steamers. In a screw steamer the depth of hold is usually sufficient to ensure ample longitudinal strength. In a stern-wheeler the fore and aft strength of the hull is admittedly weak, and special girders are usually fitted to prevent hogging. In the ordinary paddle steamer, however, the longitudinal strength of the hull is usually found to be sufficient without any girder structure above the deck if the ends of the vessel are fairly fine.

Shallow-draught steamers as a rule have a very full midship section and a long parallel middle body; it follows therefore that any increase in the block coefficient is felt mostly at the ends. This is all to the good in a stern-wheeler where the machinery is fitted at the ends; indeed, in these boats very little variation in the block coefficient can be made.

In a paddle steamer, however, the whole weight of the machinery and fuel is concentrated amidships, and consequently if the ends of the vessel be made very bluff the vessel will tend to sag and the deck will buckle when the boilers and bunkers are full and the holds empty. It then becomes necessary to build in additional stiffening, especially under the deck, to resist the compression stresses, and the question will arise as to whether the gain in carrying capacity due to the increased coefficient will compensate for the extra stiffening and complication in the holds. The whole question then resolves itself into a case of give and take, and that is still

not understood by many owners of successful vessels, who continue to ask for repeat vessels, but to carry more cargo, draw less water and go faster. This is of course nearly always possible at a price, but is very seldom advisable, and one of the greatest difficulties in designing shallow-draught vessels is to get the owners and their different experts to agree as to what is really essential and what can be dispensed with.

THE SULZER TWO-STROKE DIESEL ENGINE.

(*Concluded from page* 173.)

The scavenging air, in the Sulzer two-stroke engine is furnished either by a compressor built as part of the main engine or by an independent blower. As the volume of air required is considerable, the compressor cylinder when used must be of comparatively large dimensions and it therefore adds appreciably to the overall dimensions and weight of the engine. Hence in the case of all but small plants it is usual to provide the scavenging air by means of a high-speed centrifugal blower separate from the main engines and driven by its own electric motor. Such a blower is shown in Fig. 15, annexed, where it has been placed alongside the compressor cylinder of a combined unit in order that the striking difference in size may be apparent. Such a blower will operate at about 3000 r.p.m., while the compressor being limited by the engine speed to something like 100 r.p.m. is manifestly at a disadvantage in point of size and weight. For marine engines of over 1,000 b.h.p. electrically-driven scavenging blowers are usually fitted. The direct-driven scavenging compressor absorbs about 6 per cent. of the power of the main engine, so that by eliminating it, this amount of extra power is made available for propulsion without any increase either in the mean pressure or in the speed of the engine. The power for the electrically-driven blower is derived from auxiliary Diesel-driven generators which also supply current for lighting the vessel and for driving winches, &c., in port. As the deck machinery is not in use when the main engines are running, the auxiliary generators do not require to be of sufficient size to carry out all their duties simultaneously, and, indeed, in order to drive the blowers when at sea they need be little larger than would be necessary for ship-lighting and winch-driving alone.

Having now described the main mechanical features of the Sulzer two-cycle engine, there are certain points of design which may be considered. The two-cycle engine, as such, possesses certain characteristics in which it differs materially from the four-cycle type and these involve problems of design which are peculiar to itself. The fact of obtaining a power-stroke once in every revolution of the crankshaft, instead of only once in every two revolutions, naturally allows the two-cycle engine to be built much smaller and lighter than a four-cycle, of equal power, since, if piston speeds are kept the same, the cylinder volume need be only about half that of the four-cycle type. The piston rods, cross-head and crank pins are also proportionally much smaller, and what is more important, the crankshaft diameter can be made appreciably less because the maximum torque to which it is subjected is greatly reduced. Although a well-designed two-cycle engine can be run at the same speed of revolution as a four-cycle engine of equal power, it is usual in marine practice to adopt a somewhat lower speed for the two-cycle type. The primary object of this is to take advantage of the better propeller efficiency permitted by the lower speed, but it also has advantages in connection with the cooling of the cylinders, which is a matter of great importance, particularly in the case of an engine having a firing stroke once in every revolution. The lower speed, of course, involves a somewhat larger and heavier two-cycle engine than would otherwise be required, but the duplication of the working strokes so reduces the necessary size of the engine that even with a slight reduction in speed, the dimensions and weight are materially less than when the four-cycle principle is adopted.

To come to actual figures, it may be said that a plant for shipboard consisting of a pair of 1,100 b.h.p. two-cycle engines, complete with all auxiliaries, would not exceed about 320 tons in weight, and could be installed in an engine room 36 ft. long. A pair of four-cycle engines of equal power, with their auxiliaries would weigh 530 tons and would require an engine-room 49 ft. in length to accommodate them. It has been assumed that each two-cycle engine would have four cylinders, each 22-in. bore by 32·625-in. stroke, and would run at 105 r.p.m. The corresponding design of four-cycle engine has been assumed to be one with six cylinders, each 24·75-in. bore by 37·375-in. stroke, running at 125 r.p.m. The crankshafts in the two cases would be 13·75-in. diameter and 15 in. diameter respectively, in accordance with Lloyd's regulations. According to this comparison, the two-cycle installation would effect a saving in weight of 210 tons and give an increased cargo space of about 30,000 cub. ft., equal space for accessibility being allowed in the engine room in both cases. Unless these advantages, however, can be secured without the sacrifice of reliability or efficiency they are valueless in an installation for sea-going purposes. Messrs. Sulzer Brothers who have now built 500,000 b.h.p.

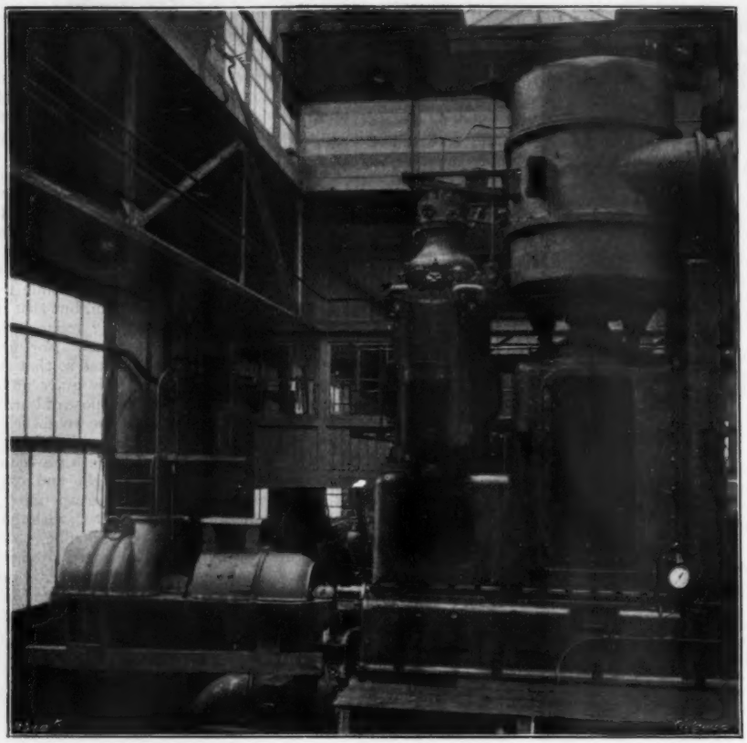


Fig. 15.—Comparison between Reciprocating Scavenging Pump and Turbo-Blower.

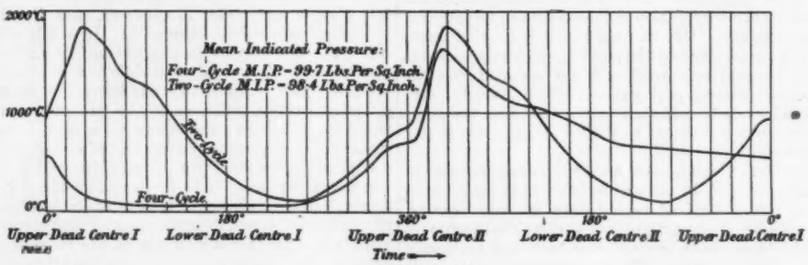


Fig 16.

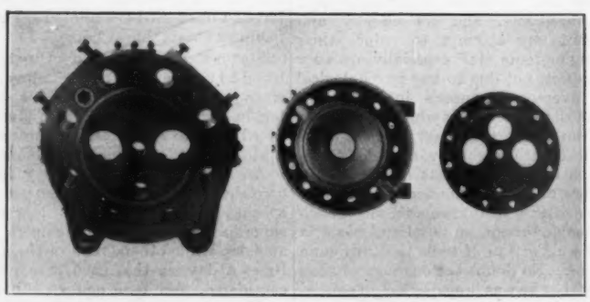


Fig. 17.—Comparison between Cylinder Head Designs.

TWO-CYCLE DIESEL ENGINES.

CONSTRUCTED BY MESSRS. SULZER BROTHERS, ENGINEERS, WINTERTHUR, SWITZERLAND.

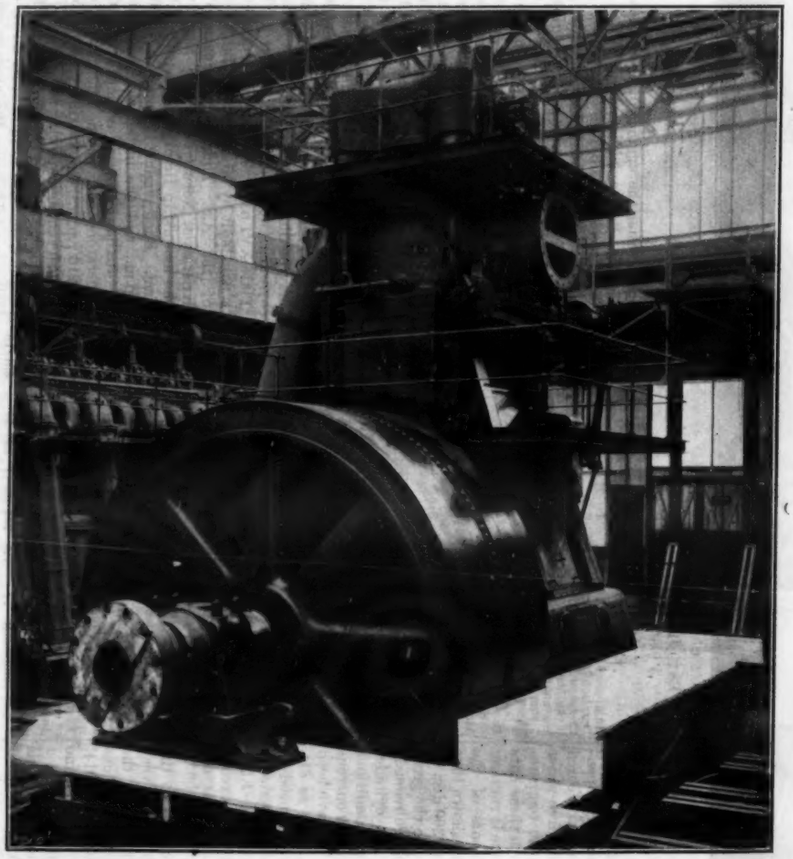


FIG. 18. 2,000 B.H.P. SINGLE-CYLINDER TWO-CYCLE DIESEL ENGINE.

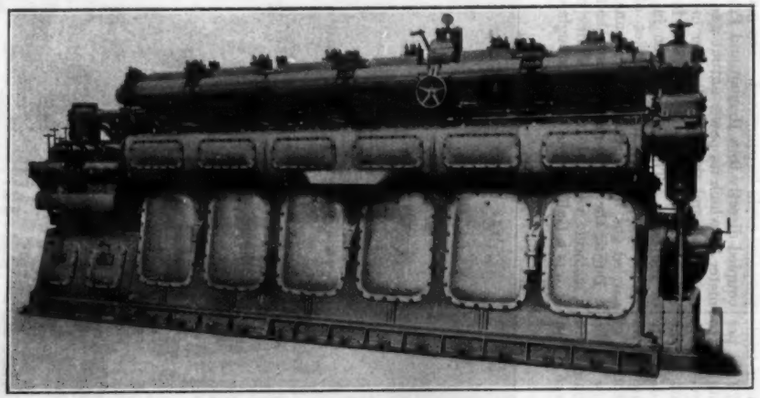


FIG. 19. 2,500 B.H.P. TWO-CYCLE SUBMARINE DIESEL ENGINE.

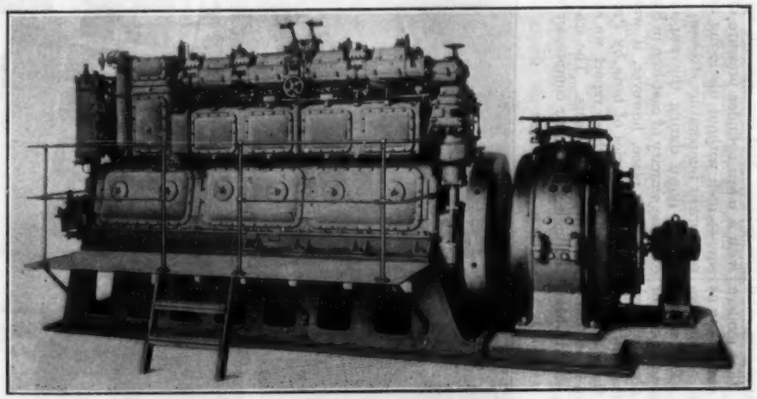


FIG. 20. TWO-CYCLE SUBMARINE DIESEL ENGINE FOR SHIPLIGHTING.

of two-cycle engines claim that experience shows their design of two-cycle engine to have at least as high a degree of reliability as the best types of four-cycle engines, while, owing to its greater simplicity and reduced number of valves, &c., its maintenance is less. As regards efficiency, there appears to be no measurable difference between the types in the matter of fuel consumption.

One of the greatest problems of the designer who wishes to take advantage of the possibilities of the two-stroke cycle, is that of avoiding temperature troubles in the cylinder. Reference to Fig. 16, page 224, will show the conditions with which he has to contend. This diagram illustrates graphically the variation of temperature within the cylinder of a two-cycle and four-cycle engine respectively, during two revolutions of the crankshaft. It will be observed that the maximum temperature reached is somewhat greater in the case of the two-cycle engine, corresponding to the slightly greater mean effective pressure at which this engine happens to be working. The important point, however, is that there are two temperature peaks in the two-cycle curve as against one in the other and consequently the two-cycle engine has to operate with much less time for cooling the cylinder between the firings. The conditions are therefore more severe than those to which the four-cycle engine is subjected, for the mean temperature of the gases in contact with the internal surface of the cylinder of the two-cycle engine must necessarily be greater than occurs in the other type. This fact is often regarded as a serious limitation to the use of two-cycle engines, but it must be remembered that the cylinders of these engines being considerably smaller in diameter than those of the four-cycle type, they may be made of correspondingly thinner metal, and the ratio of their cooling surface to volume is also greater. Moreover, the thorough scavenging with cold air to which the Sulzer two-cycle cylinders are subjected after every firing stroke has an important cooling effect upon the metal.

It is in the cylinder heads that the principal difficulties caused by high and rapidly-fluctuating temperatures and pressures are liable to occur, unless great care is taken in the design. The smaller size and much greater simplicity of the two-cycle head are both favourable features. In Fig. 17, page 224, a comparison is given between three cylinder heads, all belonging to engines of equal power. The head on the left is that of a four-cycle engine, the others belonging to different designs

of two-cycle engines. The difference in size is very noticeable. The right-hand head is that of an old type of engine fitted with head-scavenging, and the central illustration represents the modern Sulzer head. Its extreme simplicity, containing as it does only a single central opening, is very noticeable as compared with the others. The special features of this head, which is a characteristic of the Sulzer two-cycle engine, have already been referred to in connection with the illustrations on Plate XVI, published with our issue of the 11th inst., and page 171 *ante*, in which it is shown in section.

The Sulzer engine exhausts, as has already been explained, through a row of ports which are uncovered on the downward stroke of the piston. The vertical bars which separate the port openings are cast solid with the liner, and are cored out from end to end so that there is a free-water circulation through each bar. The mean temperature of the exhaust gases in contact with these bars is only about 450 deg. F. when the engine is running at full power, and careful measurements of the temperature of the bars themselves have shown that the metal itself does not rise above about 300 deg. F. These low temperatures are largely due to the great quantity of air used for scavenging, which obviously has a beneficial cooling effect on the cylinder and the port bars. The temperature conditions under which the bars work are therefore less onerous than exist in many steam engines, and we have been assured that no trouble of any kind, such as distortion or cracking, has ever been experienced in connection with the exhaust bars. As experience of the design now extends over more than 1,500 cylinders at work, of which more than 400 exceed 20 in. in diameter, it must be admitted that the design is justified by results.

In order to confirm their calculations as to the practicability of building two-cycle engines in very large sizes and to determine, experimentally, the behaviour of such engines under various conditions of working, Messrs. Sulzer Brothers, in 1914, undertook the construction of a two-cycle engine designed to develop no less than 2,000 b.h.p. in a single cylinder. The cylinder diameter for this power was 39·4 in. and the stroke 43·5 in., the speed of rotation being 150 r.p.m. This engine, which we illustrate in Fig. 18, page 225, was tested exhaustively for a period of two years in the works of the makers, and ran through several 6-hour trials with a mean cylinder pressure of over 120 lb. per square inch without disclosing any defects due to pressure or temperature stresses. It was eventually melted down during the war on account of the extreme scarcity of cast-iron in Switzerland. Before this took place, however, it was put through an exhaustive series of tests by Professor Stodola, of Zurich, from whose report we select a few of the most interesting facts. The scavenging pump and the high pressure air compressor were driven by an independent Diesel engine, from the indicator cards of which the power required for these auxiliary purposes could be computed. The main engine was coupled directly to a Heenan and Froude dynamometer by which its power output was absorbed and measured, and this and all other instruments and indicators were carefully calibrated for the purpose of the tests. The figures given in the annexed Table I are taken from a series of three tests carried out by Dr. Stodola on January 4, 1915.

During the above named tests the fuel used had a calorific value of 10,160 calories per kilogram. It was a Galician gas oil. Throughout these, and other tests, the engine, in the words of Professor Stodola, "behaved faultlessly" and the exhaust gases were invisible to the naked eye. It was demonstrated that unless the air pressure was adequate to provide proper scavenging the capacity of the engine fell away, whereas by using greater quantities of scavenging air a considerable overload capacity was obtainable. During one series of trials an average of 2,059 b.h.p. was obtained over a 6-hour test, with a mean indicated pressure of 8·6 to 8·7 atmospheres, this, so the report states, being clearly not the maximum output of which the engine was capable. The lubricating oil used for the main cylinder worked out as about 0·7 grammes per brake horse-power hour. That used for the main bearings left them at 41·2 deg. C. and was returned to them after being reduced to 33 deg. C. in a cooler.

The results obtained with a more modern engine may be illustrated by the figures of tests of a four-cylinder two-cycle engine, similar to that shown on Plate XVI *ante*. The engine in question was one of a pair built by Messrs. Sulzer Brothers to the order of the A.S. Thunes Mekaniske Vaerkslad, of Kristiania, Norway, and they are now working in the motorship Handicap constructed by the latter firm. Each engine is rated at 1,350 b.h.p. at 95 r.p.m., and the installation also included a pair of auxiliary Diesel engines coupled to electric generators, each engine being rated at 330 b.h.p. at 210 r.p.m. One auxiliary engine by itself could furnish enough power not only to supply the scavenging air and the cooling water for both main engines, but also to fulfil other duties as well. The following table gives the average results obtained

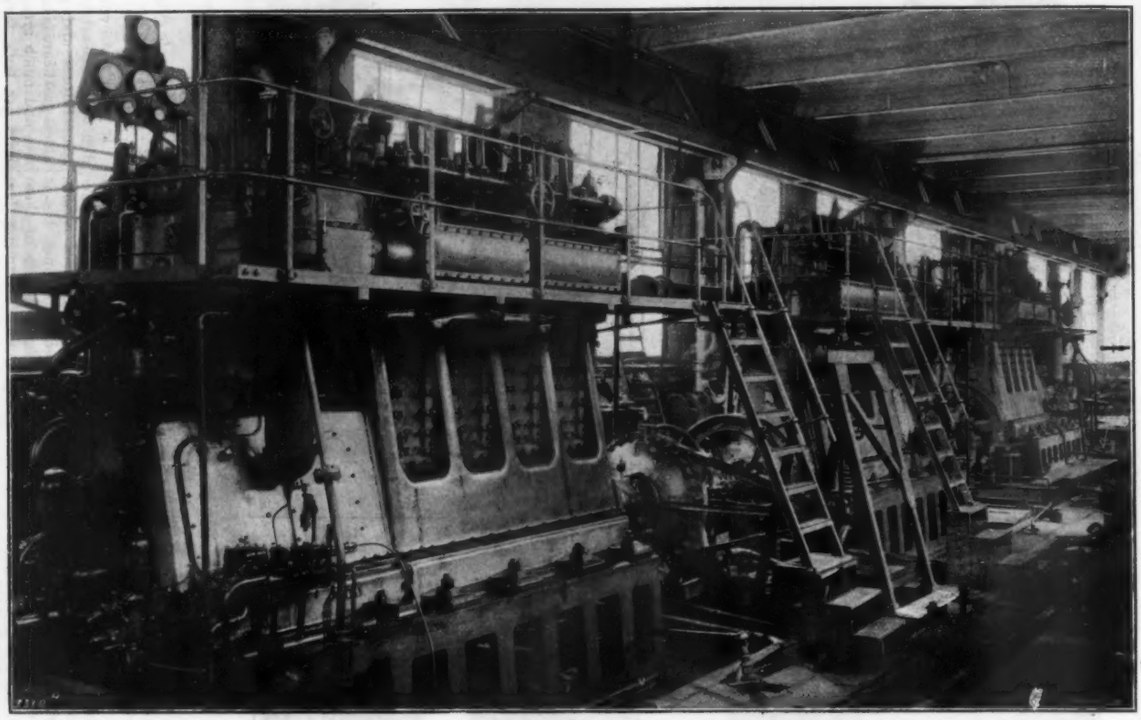


Fig. 21. One Bay of Erecting Shop at Messrs. Sulzer's Works.

Table I.

Number of test	I.	II.	III.
Duration of test (hours)	2·0	1·5	0·75
Pressure of air injection (kg./cm.²)	60·7	67·6	73·1
Scavenging air receiver pressure (kg./cm.²)	0·245	0·284	0·32
Forced lubrication pressure (kg./cm.²)	1·14	1·15	1·14
Barometric pressure (mm. Hg.)	703·0	703·5	704·0
Air temperature in engine-room (deg. C.)	15·2	15·3	17·3
Temperature of cooling water inlet (deg. C.)	8·64	8·66	8·66
Temperature of cooling water outlet from piston (deg. C.)	34·9	36·7	37·1
Temperature of cooling water outlet from cylinder (deg. C.)	38·2	37·5	38·7
Temperature of cooling water outlet from cylinder cover (deg. C.)	38·6	38·9	39·4
Temperature of scavenging air in engine (deg. C.)	39·9	45·3	50·1
Cooling water per hour for piston (kg.)	5,460	5,615	5,950
Cooling water per hour for cylinder (kg.)	5,690	5,615	5,950
Cooling water per hour for cylinder cover (kg.)	3,950	4,600	5,340
Total heat extracted per hour (calories)	430,600	550,000	576,400
Revolutions per minute	133·6	149·87	148·82
Effective output (b.h.p.)	1,453·2	1,790·7	1,986·0
Indicated horse-power (i.h.p.)	1,723·03	2,082·7	2,220·07
Mechanical efficiency (per cent.)	84·32	85·98	89·46
Fuel consumption per hour (kg.)	221·25	279·67	314·0
Fuel consumption, main engine per i.h.p.-hour	0·1283	0·1343	0·1414
Fuel consumption, main engine per b.h.p.-hour	0·1522	0·1562	0·1581
Indicated h.p. of auxiliary engine	438·38	525·72	591·76
I.H.P. of scavenging pump and compressor	204·09	297·97	351·16

during an official test of one engine lasting over 11 hours, which was carried out on March 30 last year.

TABLE II.—*Tests on Two-cycle Sulzer Engine rated at 1,350 b.h.p. Average Results.*

Load	Overload.	¾	½	¼
Average revolutions per minute	98·3	94·97	86·3	74·3
Average b.h.p.	1,635	1,355	1,012	673
Average auxiliary power	105·0	67·7	76·4	79·7
Fuel consumption, main engine, grammes per b.h.p.	181·5	180·0	180·0	179·5
Fuel consumption, auxiliaries, reduced to b.h.p.	13·4	11·0	16·4	25·6
Total average fuel per s.h.p. of main engine	194·9	191·0	196·4	205·1

During the overload test, which lasted 1·5 hours, the engine worked at an average power of 1,635 b.h.p. The full-load test, during which an average power of 1,355 b.h.p. was developed, lasted 6·25 hours. Altogether, during the 11·25 hours during which the engine was under test, a total output of 13,460 b.h.p. hours was produced. The consumption of cylinder and bearing oil for this output amounted to an average of 0·836 grammes per brake horse-power hour. The calorific value of the fuel oil used was 10,060 calories per kilogram. During the official tests, the fuel consumption per s.h.p. was measured under rather unfavourable circumstances, as the blower was of sufficient capacity for two engines, and was therefore working inefficiently. We are informed that on a subsequent trial with the blower supplying air to two engines the average full load fuel consumption per s.h.p. of the main engine worked out to 184 grammes.

Space does not permit us to deal with the various types of two-cycle engines built by Messrs. Sulzer Brothers for different duties on land or sea, but in Figs. 19 and 20, on page 225, we illustrate two types which have been supplied in considerable numbers for submarine work. The first of these is a six-cylinder engine, rated at 2,500 b.h.p., forming one of a pair of the main propelling engines. Below it is shown a four-cylinder engine, of 400 b.h.p., direct-coupled to a dynamo for lighting and battery charging on the submarine. This, it will be noticed, is a self-contained plant, the scavenging air compressor being driven from a crank at the end opposite the dynamo. In Fig. 21, on page 226, one of the testing bays in Messrs. Sulzer's erecting shop is shown, three engines being visible in the photograph. The engine in the foreground is of the four-cylinder type with self-contained scavenging arrangement.

THE DIRECT DRIVE FOR TRAIN LIGHTING.

WE have become so accustomed in this country to the excellent performance of belt-driven electric train-lighting sets that there may seem to be but little need for considering the possibility of any alternative. Our service here is, however, largely due to the very excellent organisation, both as regards train operation and as regards maintenance, which has been built up in these islands over a long term of years. It has always been here, so far as possible, the custom, especially with regard to passenger equipment, to adopt the policy of the "stitch in time," which undoubtedly where routine is regular, is the most economical. In less advanced countries, however, where traffic is not sufficiently intense to warrant elaborate organisation, or where more adverse climatic conditions prevail and sufficiently skilled attention is difficult to arrange, the belt-driven lighting set leaves a good deal to be desired. As a matter of fact, the service it gives is often surprisingly good under very unfavourable conditions, but there is no doubt that the elimination of the belt would be something of a relief to those responsible for the lighting service, under the more difficult conditions we have in mind.

The importance with which the subject is viewed in America may be gauged by the fact that a committee of the American Railway Association has been considering the subject, and in its recent report has recommended that every encouragement should be given to the development of the direct or positive drive for lighting sets. The committee was formed of either the chief, or assistant electrical engineers on the following systems: The Pennsylvania, the Norfolk and Western, the Illinois Central, the Baltimore and Ohio, the Chicago and North-Western, the New York Central, and the Chicago, Rock Island and Pacific. These are all important systems, and their representatives can be taken as speaking with authority as regards operation in the United States. In their report these officials remark upon the wide difference shown in belt performance on different roads. This is presumably due to the different amount of care which is devoted to the lighting sets on different types of roads. The reported mileage per belt varies from 5,132 to 84,775, while the average percentage of belt renewals per month vary from 5·8 to no less than 85·6.

It may be mentioned that of the lines for which statistics are given in the report, the best showing is made by the Norfolk and Western with the 5·8 per cent. belt renewals per month; at the other extreme is the Baltimore and Ohio, with the 85·6 per cent. belt renewals monthly. The B. and O. is, of course, one of the best organised systems in the United States.

As this range is so great it is difficult to select any universally representative figure, but the committee takes, as sufficiently near for their argument, a belt mileage of 10,000, and service per car per month of 5,000 miles. On this basis for the drive only the cost of new belts and of putting them on, together with one trueing of the armature pulley, would amount in the year to 43·22 dols. Depreciation of pulleys, &c., would represent 6·05 dols., and interest would represent 6·77 dols.—making a total annual expenditure of 56·04 dols. per car on parts essentially connected with the belt drive. Added to this there are other items which are difficult to appraise, including charging at terminals owing to belt failure *en route*, and damage to battery due to sulphation. Annoyance to passengers is also a point not to be overlooked, but difficult to figure out.

In summarising the requirements of a direct-driven set the committee lay down that the design should not interfere with the use of standard axles, or require the removal of a wheel from its axle to enable the drive to be fitted, or, further, interfere with the turning of the wheels in the ordinary wheel lathe. Freedom of movement of the axle in all planes is requisite, with a greater allowance for angular movement of the drive than would actually be given in service to the bogie or axle from which the drive is taken. In some of the devices tried the wear of one part has necessitated the scrapping of others. Designs involving anything of this nature are naturally to be avoided. As an instance, a chain drive functioned satisfactorily till the chain wore, when it became impossible to use a new chain with old sprockets, and all had to be renewed, whether or not there was still a good deal of life in the sprockets.

No device, the committee states, so far fulfils all requirements. Among several, however, some of which have been discarded, are one or two which give a certain amount of promise. One such device has been developed by the Gould Coupler Company, and has been in service in suburban service on the Delaware, Lackawanna and Western, and also on a dining car on the Chicago and North-Western. The first installation has operated successfully for over two years without repairs or expense beyond inspection and lubrication. A mileage of about 100,000 has been run without faults developing, or adjustment needed. The set is silent and the lighting steady with the regulator properly set. The drive consists of a gear-box carrying in large bearings a split sleeve which is clipped over the car axle. On the sleeve is formed a spur ring gearing with a pinion on a secondary shaft. The latter carries a bevel which meshes with a second one on the end of a shaft, coupled with a flexible shaft carried up to the dynamo fixed to the underframe. The whole of the gear is enclosed. Ball and roller bearings are fitted. Another device, developed by the United States Light and Heat Corporation embodies both a friction and worm drive. In this case two broad-rimmed disc wheels are clipped to the axle by bolts passing through flanges of a split sleeve which connects them. Mounted in ball bearings in a frame suspended from the bogie framing is a short shaft fitted with two friction rollers, and, between the bearings, with a worm wheel. The rollers, apparently fitted with wide rubber treads, are pulled up against the axle discs by a helical spring fitted with adjustable tensioning gear. The worm wheel meshes with a worm below, and a flexible shaft is carried to the dynamo on the underframe. The actual weight on the axle in this case is much less than in the former, which should be some advantage. Apart from the discs on the axle, and the friction rollers, the whole of this gear is also protected by casing. Both these companies, it may be noted, have had belt-driven sets on the market and in use for some time. It will be interesting to see whether drives of this type develop in the future along the lines which the American Railway Association evidently think feasible, and on which some of the lessons learnt in motor car work would appear to have a bearing.

RIACHUELO TRANSPORTER BRIDGE, BUENOS AIRES.

By P. J. RISDON.

(*Continued from page* 196.)

Superstructure.—The two main girders are 300 ft. 9¼ in. long overall, and span 254 ft. 3½ in., centre to centre of bearings, which are located centrally upon the tops of the towers. The overhanging portions, which project 23 ft. 3 in. beyond the centre of each tower towards the shore, support a prolongation of the overhead trolley tracks to enable the transporter car to be housed within the outer fendering. The girders, of which details, &c., are given in Figs. 23 to 51, on Plate XVIII, and pages 228 and 238, are of the hog-back type, divided into 13 panels, with vertical and diagonal web bracing members and raking end booms; they are 30 ft. deep over angles at the centre and 21 ft. deep at the bearings, and are spaced 55 ft. 9¼ in. apart centre to centre. The top and end raking booms consist of a pair of web plates, 33 in. deep (Fig. 27), four 7-in. by 7-in. angles and flange plates 40 in. wide, the thickness of scantlings increasing from the ends towards the centre of span. The bottom booms, Fig. 35, Plate XVIII, comprise a pair of web plates 54 in. deep and four angles 7 in. by 7 in. by ½ in. throughout, with additional reinforcing plates towards the centre panels. These web plates are connected at intervals by diaphragm plates, shown in Figs. 30 and 31. The top angles of bottom booms are rigidly laced to each other and to the track girders horizontally by transverse and diagonal angle bars, as shown in Figs. 36 to 39. The vertical web members consist of pairs of 18-in. web plates and four angles of varying thicknesses, with angle lacing bars. The diagonal web members are built up of plates and angles as shown. Fig. 29 shows the intersection of the end vertical members with the top and bottom boom.

At each intersection point the top booms are cross-connected by double-webbed lattice member (Figs. 33 and 34) which, in turn, are stiffened longitudinally, from tower to tower, by a light, curved lattice box member, shown in Fig. 28, parallel with and midway between the top booms of the main girders.

The bottom booms, at each intersection point with the web bracing, support a cross-girder of "Warren" type (Figs. 24 to 26), from which the track girders are suspended. The booms of these cross-girders, which are 6 ft. deep over channels, consist of pairs of 12-in. by 3½-in. channels, and the web bracing of pairs of tee bars laced together. From the hip joints to the ends of the cross-girders, double plate-webs, ½ in. thick, are substituted for the tee-bar bracing (Figs. 24 and 25). From these plate-webs, near each end of the cross-girder, two continuous, longitudinal, single-webbed track plate girders are suspended, on the inner side of and parallel with the bottom booms of the main girders, which support the track rails, and are so spaced that the centre of each trolley track is 5 ft. 5 in. from the centre line of main girder. An additional longitudinal trussed girder (Figs. 24 to 26) is provided on the inner side of each of the inner track girders, with horizontal N-bracing between the top flanges of the plate and trussed girders. One track girder is cross-connected to the main girder boom and the other to the trussed girder, at intervals of about

4 ft. 2 in., by transverse 8-in. by 5-in. rolled steel joists which project sufficiently into the track space to support a pair of 8-in. by 5-in. longitudinal rolled steel joists which carry the track rails; the latter weigh 85 lb. per yard and are of Vignole section. To the webs of these longitudinal joists bridge rails are riveted, so that horizontal wind rollers on the trolleys come into play before the flanges of the trolley wheels can bear against the heads of the running rails. Details of the track rail support are given in Figs. 42 to 44, annexed. The weight of the trolley upon the cantilever ends of the transverse joists is counterbalanced by the main girder bottom booms and by the longitudinal trussed girders. In order to allow for the 4½-in. camber of the main girders, the track rail joists are packed up (Figs. 42 and 43) so as to maintain a level track from end to end of the bridge. From the centre of each cross-girder a light, triangular angle bracket depends, on which are mounted 15 in. diameter pulleys for supporting the steel wire hauling rope, guards being provided to prevent the rope from coming off the pulley in case of sudden jerks. The position of these pulleys is shown in Figs. 24 and 25.

At the centre of, and carried upon each cross-girder is a vertical strut (Figs. 24 and 25) for supporting the cross-bracing members between the main girder top booms, and from each cross-girder hip joint, a raking member, consisting of a pair of 5-in. by 2½-in. channels, ensures stability, transversely, of the main girder top booms, enabling upper horizontal diagonal bracing to be dispensed with. These members, in turn, are stiffened by subsidiary vertical channels from the tops of the cross-girders.

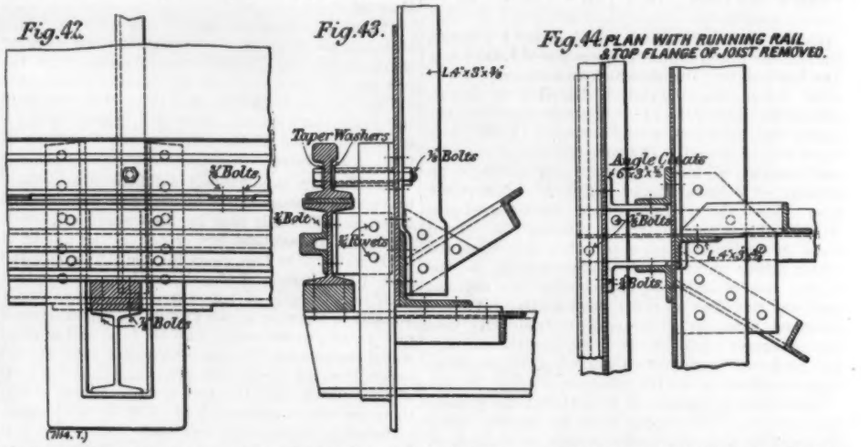
Horizontal diagonal bracing is provided between the main girder bottom booms (Fig. 26), connected by gusset plates to the upper angles of the booms and to the cross-girders. This bracing consists of rolled steel channels of varying section, tee bars being riveted to the webs in the case of the members sustaining the heaviest wind stresses.

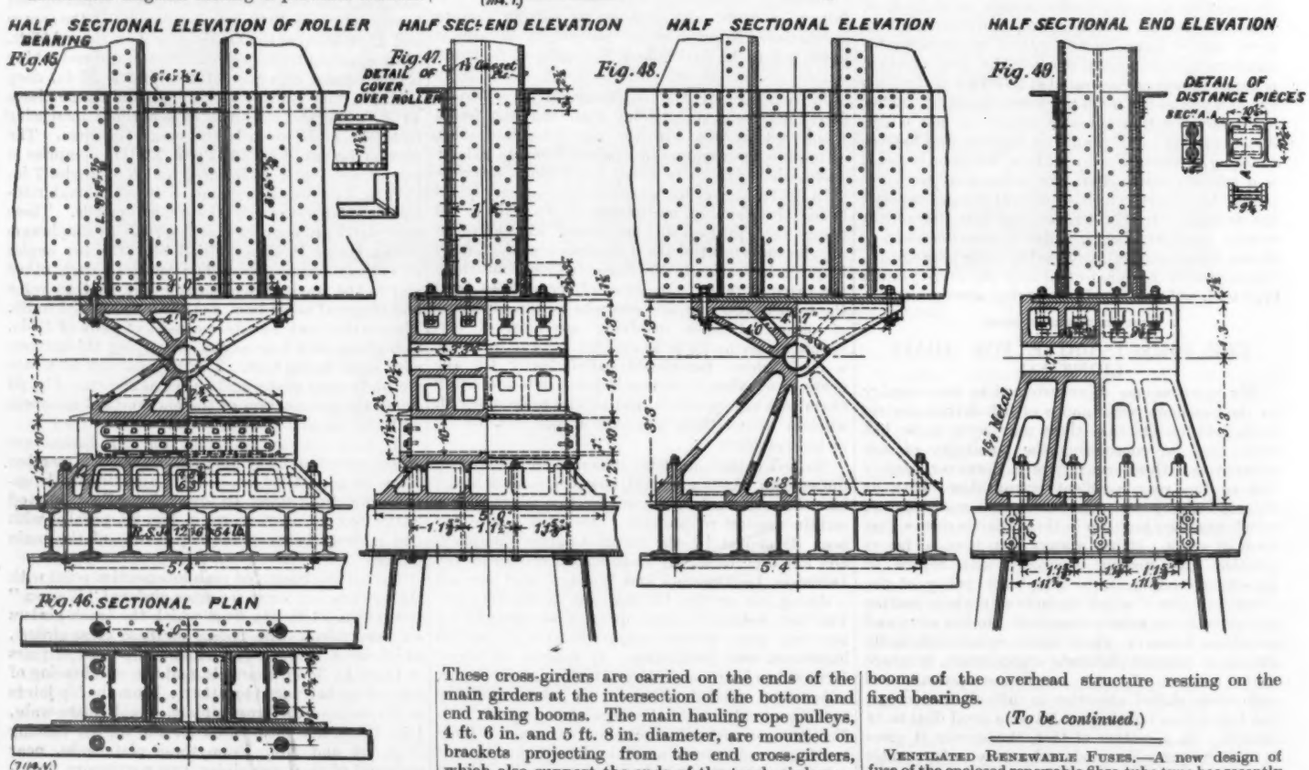
Outside each main girder, at the level of the bottom booms, a gangway and handrail is provided, carried upon the joists which support one of the track rails, these joists projecting outside the main girders for this purpose. Access to these gangways is by means of two ladders, with hoop guards, up two of the shore legs of each tower. Gangways also extend right across the bridge at each end of the main girders, forming platforms round the main end rope pulleys. At suitable intervals, transverse gangways, half the width of the bridge, lead from one of the longitudinal gangways and facilitate access to the hauling rope guide pulleys suspended from the cross-girders, already described.

The two extreme end cross-girders are 4 ft. 6 in. deep over angles and consist of two web plates, each with a top and bottom flange angle, 8 in. by 8 in. by ⅞ in. The webs are spaced 4 ft. 6 in. apart and the flange angles at top and bottom are cross-connected by 4-in. by 4-in. by ⅜-in. angle N-bracing. These cross-girders are carried on the ends of the main girders at the intersection of the bottom and end raking booms. The main hauling rope pulleys, 4 ft. 6 in. and 5 ft. 8 in. diameter, are mounted on brackets projecting from the end cross-girders, which also support the ends of the track girders.

The main girder bearings consist of massive cast-steel saddles and bedplates, as shown in Figs. 45 to 49, annexed, pivoted upon 7 in. diameter pins, resting upon rolled steel joist grillages on top of the towers, each bedplate being bolted through the grillage joists to the towers by eight bolts 1¼ in. diameter. The saddles, which are the same at the fixed and expansion ends, are secured by eight bolts, 1¼ in. diameter, to the main girder bottom booms, which are heavily reinforced by gusset plates and diaphragms over the bearings. The saddles measure 4 ft. 7 in. by 3 ft. 3½ in. by 1 ft. 3 in. deep. At the fixed end (Figs. 48 and 49), the bedplate casting measures 6 ft. 3 in. by 5 ft. by 3 ft. 3 in. deep. At the expansion end (Figs. 45, 46 and 47) is a nest of seven steel rollers, 10 in. diameter by 6 in. wide by 3 ft. 3½ in. long, which roll upon a bedplate 6 ft. 3 in. by 5 ft. by 1 ft. 2 in. deep. Sheet metal casing is provided round the nest of expansion rollers, secured to the steel castings by ½-in. set screws, in order to exclude dirt and wet, and the bedplates are cast with a lip 1 in. high all round the roller bearing surface to prevent the escape of oil and grease. A view of the overhead girder frame in the builder's yard is shown in Fig. 50, page 238, and in Fig. 51 is given a view of part of the bottom booms of the overhead structure resting on the fixed bearings.

(To be continued.)





VENTILATED RENEWABLE FUSES.—A new design of fuse of the enclosed renewable fibre-tube type has recently been brought out by the Westinghouse Electric and Manufacturing Company, of East Pittsburg, Pa., U.S.A. The special feature of the design, which goes by the name of the Westinghouse Shurvent, lies in the arrangements adopted for venting after the blowing of the fuse. By means of passages in the end caps and end washers, which are arranged to give a baffling effect, the flow of gas from the arc is retarded sufficiently to maintain enough pressure in the cartridge to extinguish the arc and to ensure that the gases leave at a sufficiently low temperature to eliminate fire risk or danger to the operation. At the same time the provision of the baffled passages forms a vent and prevents the gases penetrating into the end screw threads or elsewhere where they may damage the fitting of the cartridge and reduce its useful life.

HENRY VIII AND NATIONAL DEFENCE.

By A. W. Johns, C.B.E., R.C.N.C., M.I.N.A.

(*Concluded from page* 198.)

As with guns, so with gunpowder, earlier kings had to purchase their supplies from abroad. By the time of Henry's accession the making of small quantities of gunpowder was being carried out in this country, and principally by the gunners of the Tower, who were supplied with the raw material and paid about ½*d.* a pound (7 marks for a last) for preparing and mixing. The price of purchased gunpowder was 3½*d.* a pound. Porchester Castle, near Portsmouth, was the chief manufactory, but there was also a small depot in London named Gunpowder House, near the Hospital of Our Lady, Bishopsgate Without, at which powder was made. The composition of gunpowder at the time is not stated, but a century later the contract for supply to the Tower of London specified it as six parts of saltpetre, one of brimstone and one of coal (charcoal ?), and it is probable the proportions had not appreciably altered. Brimstone and charcoal were obtainable in England, but the greater quantities of saltpetre required were not, and in the first few years of Henry's reign large quantities were purchased from Italian and Dutch merchants. Henry recognised the weakness of this dependence on the Continent—the saltpetre ordered in Italy was held up by the Spanish authorities, and only released on the representations of the King of Arragon, Henry's father-in-law—and in 1515 Hans Wolf—described as foreigner—was appointed one of the king's gunpowder makers in the Tower, and instructed "to go from shire to shire to find a place where there is stuff to make saltpetre of." The search does not appear to have been very successful, and in July, 1531, Thomas á Lee, one of the king's gunners, was appointed "principal searcher and maker of saltpetre with power to dig and search for the same in the king's lands and elsewhere. The said Thomas is to replenish and make up plain all ground broken at his own cost, so that the owner is not injured." He was authorised in the king's name "to hire workmen to take wood for burning and trying the saltpetre, with carriage of the same by land and water, and to take any house or houses at reasonable rent with all other necessaries and commodities." No great success attended the further search, and large quantities of gunpowder had to be bought in Antwerp for the Scotch and French wars.

The same difficulty as to the supply of saltpetre was experienced by Queen Elizabeth, and in 1561 she entered into an agreement with a German captain named Gerard Honrick to make saltpetre in England. In 1575 Francis á Lee—now Leigh—son of the Thomas before mentioned, and one of the queen's gunpowder makers, petitioned the Privy Council. He pointed out that no gunpowder was being made in England, and it had to be purchased abroad "which in the Duke of Alloa's time was stayed." Leigh then made 100 lasts of powder with saltpetre from the realm, and sold at 8*d.* and 9*d.* a pound, by which 4,000*l.* was saved. The queen, however, preferred to pay 10*l.* a last more for foreign-made stuff which often spoiled because the saltpetre used in it was not refined. Leigh begged the Council to grant him a licence to import 20 or 30 lasts of saltpetre a year, as he had all the implements for making gunpowder and he, his father and brother had for fifty years been the greatest dealers. In the following year John Bowyat was granted a patent for twenty-one years for making saltpetre from stone material not hitherto used, "instead of earth and mudwalls," the same being without moisture and not furring ordnance. In 1577, 20,000*l.* was voted for the purchase of saltpetre and gunpowder on the Continent, and probably some of this was used against the Spanish Armada. In December, 1588, a survey of the saltpetre and gunpowder in the Tower and in London was made so that quantities of the former material could be supplied to John Evelyn and Richard Hall, who then had a contract for supplying gunpowder to the Tower. The supply of powder was not, however, put upon a satisfactory basis until 1604, when a contract to make and supply it for twenty-one years was given to John and Robert Evelyn and Richard Harding. This contract was renewed with John Evelyn in 1624, the quantity specified being 20 lasts a month, the cost being about 1,700*l.*, or 8¼*d.* per pound. In 1627 Evelyn stated that he and his forbears had been supplying gunpowder for sixty years, so that probably he was a descendant of Thomas á Lee, or Leigh.

Henry VIII was recognised as an authority on artillery, and it is not without significance that a classic treatise "The Art of Shooting," written by an Italian savant, Tartaglia, in the sixteenth century, was dedicated to the king. There are indications in the State Records of the king's activities in such matters. The Basiliscus, the 15-pdr. gun cast by Walker in 1514, was the king's own design, and in September, 1538, William Hunt, a gunner in the Tower, was paid 25*l.* for "making and finishing of the king's highness device of certain pieces of artillery." In 1523 a report in Italian to the king mentions a new material, which was being used for the construction of guns and by which the weight was very substantially reduced as compared with that of guns cast with the older metal. A 60-pounder gun had its weight reduced from 10,000 lb. to 6,000 lb., and a 36-pounder from 5,500 lb. to 3,500 lb. The new material had been suggested by a German and contained less tin then formerly used and also was subjected to a hardening process.

In 1518 Henry inspected some Venetian galleys which had called at Southampton. The Venetian Ambassador who accompanied him reported to the Doge, "The king had all the guns fired again and again marking their ranges as he is very curious about matters of this kind."

Henry's representatives on the Continent had orders to keep him informed of all new developments which came to their notice. An interesting report is that of Wallop, who, in 1543, wrote that the Emperor of Spain, in laying siege to a town, was using great mortars "which fired shot filled with wildfire and 40 or 50 shot of guns within them, every one of which would kill a man. These have been heard to shoot (*i.e.*, burst) after they fall in the town, and each costs 30 guilders." In 1546 Gundelfinger, Henry's agent in Augsberg, informed the king that he wrote some time ago of a device for field guns which is very handy, and recommended that the inventor who was the Bavarian master of ordnance, should be invited to England to show and explain it to the king.

Two other reports are of some interest. In January, 1540, the French Ambassador in London wrote to his superiors that the king had come privily to London for two days to see "certain war machines and instruments for throwing fire" invented by some Germans and Italians then in London. The second report is from the Spanish Ambassador in 1541, who wrote "There is an Italian here aged about 70 who has shown the king that he would make a mirror and place it on the top of Dover Castle, in which mirror could be seen all ships that leave Dieppe; although it seems incredible, he has persuaded the king to provide the money to make it, and left yesterday for Dover to fulfil his promise." Neither the name nor the fate of the aged Italian is given, but it is a very early instance of the proposed use of a simple periscope and indicates that the inventor was then, as now, abroad in the land and was able to persuade someone to adopt his devices.

In 1515, for the purpose of encouraging gunnery, the king granted a licence to Cornelius Johnson, master smith, and William Ive, gunner in the Tower, to found a perpetual guild in honour of St. Barbara in St. Katherine's Church near the Tower, and also a mortmain licence to acquire land to the annual value of 10 marks for the support of a chaplain to the guild. Cromwell's accounts for 1539 include a payment of 4*l.* to the "Brothers and fellowship of Gunners," but the guild was not so successful as that for the encouragement of the art of navigation, the Guild of the Holy Trinity, founded the year previously. In 1582 a petition was presented to Queen Elizabeth praying for the incorporation of a company of gunners, and pointing out that it would result in an increased number of skilful gunners being available for service in the queen's ships and forts. From this it would appear that the Guild of St. Barbara had been dissolved.

In April, 1537, the king granted a licence to Sir Christopher Morris (master of ordnance) and two others, overseers of the fraternity of St. George, to be overseers of the science of artillery, "to wit, longbows, crossbows and hand gonnes," of which science Morris, Cornelius Johnson, Anthony Antony (gunner) and Henry Johnson (master gunner) shall be masters and rulers," and also to the four named to found a fraternity of St. George to be incorporated as the fraternity or guild of artillery of "longbows, crossbows and hand gonnes." Members were to be free to exercise their weapons in the City of London and all other places except the royal chases and parks. They had to wear a uniform and were exempted from serving on inquests and juries. This was the inauguration of the Honourable Artillery Company. It is not definitely stated if the members were responsible for an Act passed a few years later forbidding shooting in the woods around Westminster, in which game was becoming scarce.

In another branch of military engineering Henry also possessed some knowledge and this was in the laying out of fortifications. All plans—termed "platts" in those times—were submitted to the king and were generally very considerably modified by him before being proceeded with. Usually an explanation as to the reasons for the alterations were returned with the modified plan. The defences of Calais were continually being altered, new fortifications were erected at Portsmouth, Berwick, Queenborough and many other places, and their arrangements and details gave scope to a monarch who had original ideas on such matters.

The king also took active steps to extend and improve the mining industry. In 1528 Joachim Hoegstre was appointed principal surveyor of all mines in England and Ireland, and on taking up the post made certain proposals to the king. Hoegstre and six other Germans who understood mining work were to commence operations with 1,000 men. A foundry was to be built at Combe Martin in Devonshire, which was to be placed under Maistre Pierre and another German. Hoegstre had power to levy men as he required, and the men engaged on the work were prohibited from carrying arms on pain of losing a finger. What success attended these proposals is not clear, but the king's payments during the following years include sums for the king's iron mines at Llantressant in Wales. In 1529 there is a payment to Hugh Boywell, Nicholas Crazer and Hans Born, sent to "search the king's woods and mines in Devon, Cornwall and other parts to try and melt the ore." In September, 1538, the king's iron mine in Suffolk is mentioned. In 1542 George Byrche, king's servant, was ordered to search for and dig ores in the northern parts of the realm "where they are said to be numerous." He was to be allowed by landowners to take 400 lb. of each kind of ore and make a certificate (? analysis) thereof and all justices and officers were ordered to assist him. Five months later he was directed to go to Wales to dig for ores, it having reported that lead had been found there. In 1545 Byrche was rewarded for his services. In the same year Gerard Harman, a German goldsmith, was appointed overseer of the king's mines with wages of 2*s.* a day, and Hans Herdygen "master of the sayes of our mines" at 40*l.* a year. William Fuscombe one of the king's miners, with wages of 10*l.* a year, is also mentioned. In 1546 Joachim Gundeefinger, king's agent at Augsburg, reported to Henry "The smelter, mining surveyor and man skilled in mining work whom your majesty commanded me to send, tarried on the way and have not reached England." Joachim had spent 168 crowns, part of which he paid the three men for expenses and the remainder had been allowed their families. In the same year 1,000*l.* was granted by the Privy Council for prospecting for mines in Ireland. Thomas Agarde, Gerard Harman (the king's overseer) and Hans, a Dutchman (probably Herdyger), were sent over to search. The Privy Council later stated the three men had brought back "sundry pieces which they had founde both for coyne and allome which being seen (by the Council) and founde to be fayer were appointed to be kepte and the king's further pleasure learnt." It is probable that the king's intention was to discover

mines from which copper could be obtained, for that material had to be bought in considerable quantities on the Continent. Just before the French war, John Osbourne, Comptroller of the Navy, and Robert Owen, the gunfounder, were at Antwerp, and purchased nearly half a million pounds weight of the material, and in 1546 the same quantity was purchased for 20,000*l*. A hope of discovering gold was probably also an active incentive in Henry's mind, for money then, as now, was generally scarce. Elizabeth followed her father's example in opening up and developing the mining industry. At first this work was placed in charge of Parson Thurland, master of the Savoy Chapel, who was assisted by a number of German experts. Later, complaints arose as to the affairs of the Savoy, and these led to the dismissal of Thurland. Two of his assistants named Hochstetter and Louver, were then placed in charge. Copper was discovered near Keswick, in Cumberland, stamps and furnaces were erected and considerable quantities of the metal were obtained. Iron was found in the Forest of Dean, a coal mine near Bristol, lead in the Mendip Hills, and copper in Cornwall. The copper was sent to Neath, in Wales, where a furnace had been erected for smelting. Gold was also reported to have been discovered at Crawford Muir, in Scotland. In 1570 "a Company of the Mines Royal" was formed for taking over and working the mines which appeared likely to be profitable.

Not content with the native productions, an effort was made to bring ores from abroad and treat them in this country. Marten Frobisher, the famous seaman, made three voyages in 1576, 1577 and 1578 to a land called Meta Incognita, which was probably Spitzbergen. On the first voyage he brought a small quantity of ore which the assayers stated contained gold. A larger quantity was brought on the second voyage, and the third was specially made to bring back 2,000 tons. Furnaces for smelting the ore were erected at Dartford, in Kent, but the venture did not prove a commercial success and the venturers in the three voyages, amongst whom was the queen with 1,000*l*., had little return for their money. The venture was not repeated, but Frobisher was given the reversion of the post of clerk of the ships on the resignation or death of the holder.

It is probable that if a more careful search were made of the State Papers than has been possible to the present writer, many more instances of Henry VIII's interest in engineering matters might be brought to light. It is thought, however, sufficient has been said in the foregoing to show that the king took far more than a passing interest in nearly all branches of engineering which then existed, and by his initiative and example encouraged and considerably improved them. In doing so he materially strengthened the national defences.

The Production of Carbon Black.—Carbon black is used extensively in the rubber industry, something like 20,000,000 lb. going annually into the manufacture of automobile tires. From 10,000,000 lb. to 12,000,000 lb. of carbon black are used annually in the manufacture of printers' ink, and from 4,000,000 lb. to 5,000,000 lb. in the making of stove polish. The product enters also into the composition of black and grey paint, phonograph records, carbon paper, crayons, typewriter ribbons, glazed paper, tarpaulins, black leather, artificial stone and insulating materials. In normal times, the United States export probably 10,000,000 lb. of carbon black in a year. Carbon black is the fluffy, velvety, black pigment produced by burning natural gas with a smoky flame against a metal surface. In its physical characteristics it is entirely different from lampblack, which is made by burning oil or other carbonaceous material with insufficient air and collecting the smoke in settling chambers. The process of manufacture most widely used at present is the so-called channel system, in which the black is deposited on the smooth undersurface of steel channels by lava-tip-burners. The apparatus is enclosed in sheet-iron buildings in order that the amount of air may be regulated. The first factory in which carbon black was successfully made on a commercial scale from natural gas was erected at New Cumberland, W. Va., in 1872. Until the utilisation of gas from the prolific gas fields at Monroe and Shreveport, La., 75 per cent. of the world's total supply of carbon black was produced in West Virginia. Increases in the price of natural gas in that state have, however, caused some manufacturers to move their plants to more isolated districts, where the gas, because of the lack of other markets, is cheap. Thus the Monroe gas field in Louisiana has become an important centre of carbon black plants. Factories are located also in Wyoming, Oklahoma, Montana, Kentucky and other states.

THE NATIONAL PHYSICAL LABORATORY.

(*Concluded from page* 214.)

Workshop (Mr. A. J. C. Brookes).—The standard gauges now made in the Laboratory workshop (in addition to the various machines) rank with the most reliable produced anywhere, and the new sets of flat-ended length gauges in particular are a distinct improvement on any type of bar gauges previously met with. It is much to be regretted, therefore, that the staff of the workshop had to be reduced so that the full value of the department is not being realised. The difficulties of generating the sub-divisional lengths of the blocks and slips from one parent standard have been successfully overcome with the aid of the auto-lapping chucks and jigs and the level comparator of Mr. Brookes and other devices.

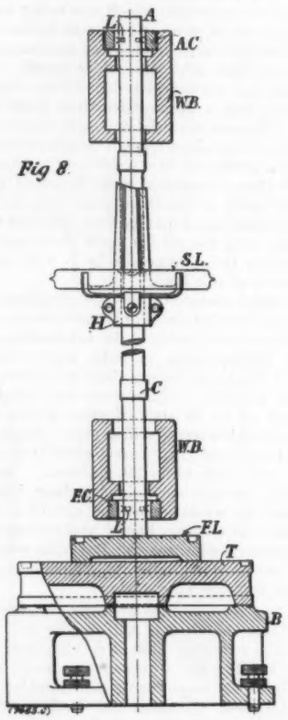


Fig 8.

Unless the surfaces are really flat, parallel, and square to the axis of the bar, it is manifestly impossible to give an accurate length to the bar. The system of production adopted is largely automatic, self-checking and by no means costly, and the account of this work, it is stated, forms perhaps the most valuable part of the report from the Metrology Department.

Making Slip and Block Johansson Gauges.—Gauge blanks are made in sets of eight, and hardened and ground to about 0·005 in. oversize. They are then placed upon the eight facets of an octagonal magnetic chuck plate (the facets of the chuck having previously been lapped into one true plane), one on each facet, and are all lapped together upon a true lapping plate, turned by hand or by motor. The blocks are then reversed, and the other faces are lapped; the exposed faces of all the gauges will now be in one geometrical plane, and those on the other side (in contact with the facets) will be in another geometrical plane. But these two planes will not, except by something like a miracle, be truly parallel, and the blocks will hence not be of the same mean thickness. A simple cross-corner interchange in position of some of the gauges will, however—provided the gauges be all equally hard—make a new pair on any corner of the chuck of exactly the mean thickness of any other pair, and further interchanges and a third lapping will generally finish all the gauges flat and parallel and of equal size within 0·000001 in. When they are thus finished they will wring together and can be tested in piles by the aid of the general comparator, presently to be described, or by more simple level devices of the same type. A system of interchanges has been worked out.

Lapping Jigs for Longer Gauges.—The jig illustrated in the diagram, Fig. 8, is only used for the final finish of the measuring faces of bars up to 36 in. long, the object being to get the faces truly plane and parallel and square to the longitudinal axis of the bar within 1 or 2 millionths of an inch, and of correct length within the same limits. The bar A rests on a base B and is held by two wall brackets, W B, which are essential to the mounting. The finished collars C, marked on Fig. 8, are not wanted for the lapping or measurement in the vertical position, but would be wanted for measurements with the bar in a horizontal position. These collars C, which are simply turned on, mark the Airy points of minimum deflection. The bar is held by the adjustable collars A C, and lugs L, which are finished cylindrical surfaces. The sensitive level S L is clamped to the true cylindrical surface of the bar by means of the holder H. Between the lower end of the bar and its base B is the cast-iron lap disc L, the upper and lower surfaces of which must be finished plane and parallel, and the rotating table T. The surfaces of L and T are well lubricated; L is generally moved by hand in lapping, and the movement is so gentle that no sound is heard during process. The two chief adjustments required are the accurate levelling of the rotating table and the verticalising of the axis of the bar; this latter adjustment is obtained by moving the adjustable collars A C until the bar can be turned about its vertical axis without causing any displacement of the bubble of a sensitive level temporarily attached to it.

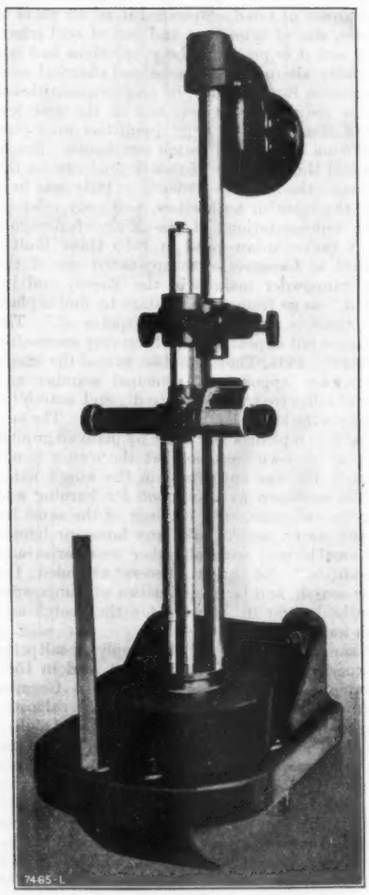


Fig. 9.

General Comparator.—The general comparator, with the aid of which the results of the lapping processes are checked, is illustrated in Figs. 9 to 15. The comparator is mounted on a rigid foundation and on to the face of a 14-in. wall,

any instability of which it would itself indicate. The bars or gauges to be compared are placed side by side upon a rotating table, their relative heights or lengths being then compared directly by means of a precision spirit-level mounted upon a base, in the form of two ball points spanning across the ends of the bars, as indicated in the diagrams, Figs. 10 to 12. The level, the indicator of the machine, can be moved in all directions. In spite of their extreme high accuracy those machines are simple and inexpensive to make, and they have the great advantage that the personal element and temperature

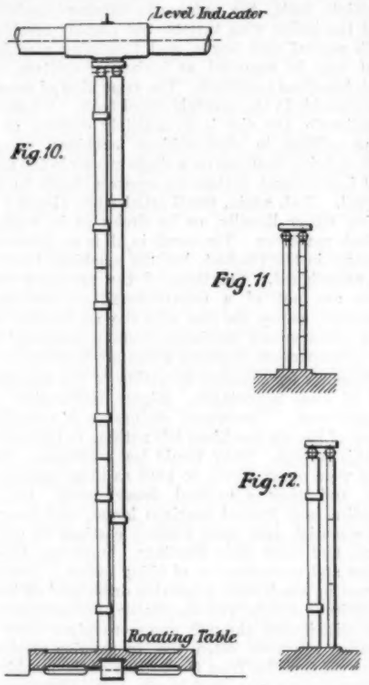


Fig. 10.

Fig. 11.

Fig. 12.

influences are eliminated as far as possible. The standard and the gauge will be at the same temperature when compared in this machine, and there is no need of conducting measurements at some standard temperature, provided the two materials have the same coefficient of expansion; under these conditions all bars derived from the same parent will be true to size at the temperature at which the bar is correct.

The rotating table (Fig. 13) is to perform an accurate interchange in position, in relation to the level indicator, of any two end bars or pieces when being compared. For this purpose the table is turned through 180 deg.; the indicator can thus be used in a differential manner, while the machine becomes self-checking. A number of pieces can be compared at one setting, and once the pieces are placed on the table they need not be handled any further. The solid block *a* of the table is provided with an annulus *b* on its lower surface which corresponds to an annulus on the base; the spigot *c* fits loosely. To facilitate the lapping of the symmetrical facets *d* on the upper face an annulus is also provided on the upper side of *a*. All the working surfaces are case-hardened, ground and lapped, and parallelism of the upper and lower surfaces is secured by means of a delicate method of lapping developed in the workshop and known as "spot grinding." The mounting of the indicator is illustrated by Figs. 14 and 15 in which *a* is the tube of the level in its aluminium sleeve *b*; the base, coming into contact with the gauge or bar, is formed of the two balls *c* which are adjustable, relative to the level tube, by means of the fitting *g*. When out of use the level rests on two adjustable points *f* and f_1, and is supported by the third point *d*; when the points *e* are brought into contact with the ends of the bar by lowering the sleeve *h*, the points f_1 f_1 are taken out of contact; the level then rests freely upon the top of the gauges, but is still prevented from rotating about its own axis by the third point *d*. Point *f* fits into a conical hole, f_1 into a V-slot. This mounting renders the indicator independent of any distortion in the machine or any temperature change; at the moment of measuring the indicator is practically out of contact with the machine resting freely upon the top of the pieces. The level tube in use has a radius of 800 ft. which, on a distance of 0·4 in. between ball centres, gives a magnification of 48,000.

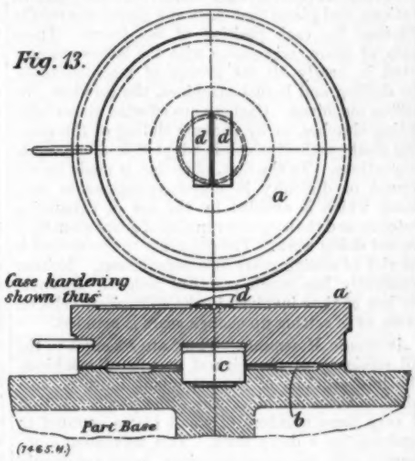


Fig. 13.

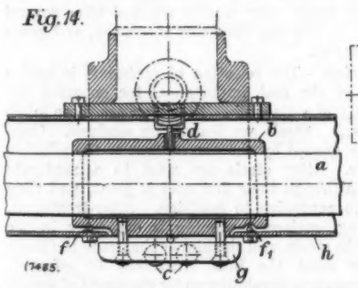


Fig. 14.

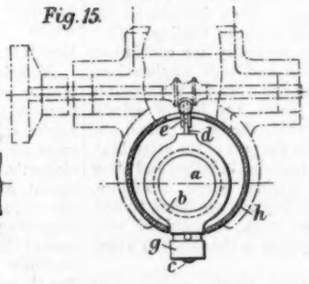


Fig. 15.

Fig. 16.

We finally mention another application of wrung discs suggested by Mr. Brookes. It is difficult to determine the exact coincidence between the end of horizontal bar and the scale; thus there may be an initial error greater than the subdivisional errors. To facilitate this end-reading Mr. Brookes wrings together a disc *a* and a ring *b* fitting over the bar *c* (Fig. 16), so that the combination forms a cap on the end of the bar, which bears closely against the disc *a*; the line of contact between the disc and the ring-marks the end of the bar much more distinctly than direct observation of the bar would do.

THE PORT OF PARIS.—The French Minister of Public Works, M. Le Trocquer, received recently a delegation from the Paris Municipality, and, in answer to their request, promised to expedite the work in connection with the building of a wharf at Bercy-Charenton, the ports of discharge at Gennevilliers and Bonneuil, and the lengthening of the Ourcq Canal up to the Nuth Canal. The attention of the Minister was also called to the question of weirs on the Upper Seine, the derivation of the Marne, the deepening of the Seine, and other points. These other matters are being considered also.

MACHINE TOOLS; THEIR DESIGN AND MANUFACTURE.

By JOSEPH HORNER.

A GIBBON of the distant future, laborious in research, accomplished, and possessing a rich and polished style will devote a fascinating chapter to the triumphs of machinery in the twentieth century. Antiquarian researches have dealt with the ages of rude and polished stone, of copper and bronze. The age of iron has been followed by that of steel. The present is the nascent age of the alloy steels, without which much of the machinery now constructed could not endure the severe and prolonged stresses imposed on it.

To realise faintly the extent of the change that has been accomplished by modern machinery—modern in the most absolute sense—we must remember the conditions that prevailed in pre-machinery eras, when every article was made by hand, slowly and expensively, eras when the few luxuries that were available were reserved for the wealthy few, and when daily misery and recurrent famine made havoc in the ranks of the labourers. Those were periods when the common comforts, the foods, the housing, the clothing and the luxuries, the travel facilities, which all now demand by right and which the majority enjoy, were not within reach of prince or peer. Machinery—employing the term in its fullest sense—has wrought this marvellous change.

Even so recently as the publication of the great French encyclopædia of Diderot, a study of the plates reveals how extremely small a part machinery, outside the lathes, played in the operations of manufacture. There were hand tools in abundance, many being scarcely distinguishable from those in use at the present day, but the great groups of present-day machine tools had no prototypes. All, except lathes and drill presses, were invented in the early years of the nineteenth century. When that century closed, the representative machine tools differed in a considerable number of important details from those which are now regarded as advanced types. Those of twenty years since are more suitable for general shops and small products than their successors. Several causes have combined to evolve the new designs, which in some of their aspects present strong contrasts to their immediate predecessors.

Increased Complication of Machine Tools.—In their highest developments, these are no longer the comparatively simple mechanisms that admit of ready treatment and elucidation in the compass of a brief description, or of a few short paragraphs. Facility of operation and the simplification of the tasks and movements of the attendant entail the multiplication of parts of self-acting or wholly automatic movements, an increase in the elements, with lessening of personal responsibility. A result of this elaboration is that the great groups of tools are becoming so highly specialised that they can only be built successfully and profitably by firms who specialise. One by one they drop the construction of machine tools in general to concentrate on a few, or often on one class of tool only, and this in a limited number of dimensions, light, or heavy. The design of a new or modified tool involves many subsidiary matters which collectively contribute, and lead up to, the ultimate result desired, which is summed up in the word "efficiency." This does not suggest that the prototypes were not efficient, for their performances were marvellous. But by comparison, in contrast with their present-day successors they were wasteful of time and incapable of accomplishing the results that are now required as common places in tooling. The changes are rather those of a revolution than of evolution, since little of the old is embodied in the new save the broad outlines and the general character of the operations performed.

Changing Aspects of Tooling.—The growth of the later tools has been so phenomenally rapid, and the aspects of that growth are so varied that the subject becomes increasingly difficult of treatment. One arresting aspect is that there are two great groupings of machine tools, those built for general service, and those for specialised products only. Another is that the view-point of the operations performed has been shifting. At one time certain work was

always sent to a certain machine, which by conservatism of attitude, sanctioned by long use, was deemed sacred to that particular class of tooling. This obstinate attitude delayed the growth of a better practice. It hindered the growth of precision grinding of all kinds. It delayed the practice of milling. It also hampered the advance of cutting with many tools in back and front posts of the lathe. It sent all screws, short as well as long, to the screw-cutting and turning lathe, all gears to the univeral machine or the milling machine. The self-acting sliding, surfacing and screw-cutting lathe tyrannised over the tooling of cylindrical and circular parts, between centres, and on the face-plate. The planer, shaper and slotter took toll of all the plane surface tooling and grooving. Articles were also treated individually after having been marked out, and bolted to the tables with tentative settings and adjustments, and tooled with no guidance save that of the setting of the tools by the attendant. When broaching machines were introduced they were small and light, cutting key grooves only. By the growth of grinding and of milling practice the dominance of the old machines was challenged. They became modified and improved, and took on a new lease of life, but not until much of their old work had been permanently appropriated by their rivals. When the screw machines, and early turret lathes came into use they were not as yet serious rivals to the common lathes, but when they grew both in capacity, and extension of operations, and in power, they took away permanently large volumes of elaborate tooling from the old standard lathes. And now the sphere of the turret lathes is being invaded by the automatic turning machines, satellites to the turrets—roughing-out work for the latter, or for the grinder. The common lathe, and the boring machine, are also roughing tools preparatory to the grinding in the latest practice. These changes are little less than revolutionary.

Aspects that are Common to all Machines.—Although there is a very broad distinction between machines built for general purposes and those for specialised manufacture, they now must possess some aspects in common, which are necessary to their efficiency. Capacity for high production must be combined with durability. The first involves the details of design, construction and manufacture, facility of operation, self-acting, or automatic movements, and tool equipment and arrangements. The second includes in addition questions of greater care in proportioning of parts, of selection of materials, and the treatment to which they are subjected, and the methods by which parts are made mutually fitting. A wide subject truly!

Increased Output.—The problem of output is largely linked with the employment of tools of high-speed steel, and later, those of Stellite. But it would have developed if these innovations had not occurred. Increased output is secured not alone by the greater cutting capacity of tools, but also in the adoption of higher speeds and coarser feeds, and in the multiplication of similar operations, once performed separately, but now simultaneously, or in rapid succession. A result is the large absorption of power which the new machines require, when a comparison is made between these and the earlier designs. This renders belt changing more laborious, so that a belt when retained is used only for the main drive without change of speed. It is wide, and driven at a high speed. Or a motor is employed. In the heavier machines various movements are taken charge of by different motors, each rated to its special duties, as are those on cranes.

Stronger Machines.—Increased power demands that greater strength shall be given to the machine throughout. Flimsily built designs were the rule in the past. Now questions arise as to the best dispositions of the added metal. Weight alone is no guarantee of efficiency, which from this aspect means ability to withstand the most powerful drives, and the heaviest cutting without vibration and chatter which are fatal to accurate results, particularly in the machines of highest precision, as the grinders. This is the problem, and not that of strength. Weight must be distributed with good judgment born of experience, in framings and other elements, and stiffness in shafts, and in designing new and modified machines some experiments may have to be made. It may therefore happen that a lighter machine, rationally designed will be more efficient than one much heavier in which the metal is lumped in parts where it is not required. Yet to some purchasers the heavier machine might appeal to the detriment of the other. Some of the advanced firms take prospective purchaser into their confidence, and show by photographs and drawings the methods by which rigidity and efficiency are secured.

Readiness of Operation.—Facility of operation is an element in efficiency. It is being recognised that the movements of the workman and his responsibilities must be reduced to the minimum practicable if the machine is to be made capable of yielding the highest production which is desirable or possible of achievement. This has resulted in a variety of time-saving arrangements which enable many movements for effecting speed and feed changes to be accomplished without any shifting of belts, or the slow fixing up of change gears. The speed and feed change gears enclosed in boxes are engaged by means of levers having locking holes for the various stations, and plates that show at a glance the results obtained for each position of the levers. These nests of gears, originating with the lathes are now fitted in nearly all the groups of machine tools, the drilling and boring machines, the grinders, the milling machines. Changes are effected either with sliding clutches, or by endlong sliding of the gears into mesh, each of which is adopted in about equal proportions. To the first, objection is made on the ground of difficulty in clutch engagements with claws, which is avoided by the use of expanding clutches, and the constant running of gears when they are not doing work. The objection to the second is the risk of sliding gears into engagement. Neither apparently has much practical weight. In each, the loss of time involved in the shifting of belts on cones, or of setting up change gears is avoided.

Automatic Movements.—These are essential to the full efficiency of the highest groups of machines. The interventions of the attendant must be curtailed in those machines where the product is that of very large numbers of small pieces counted in hundreds for a day's work. This movement commenced with the screw machines, hence commonly termed automatics simply. They introduced the cam system on drums and discs for feeding. They also embodied a scheme necessary for continuous work, and one which has had wide applications, that of the substitution of bar work for the separate chucking of individual pieces, the hollow spindle being provided through which the bar is passed and fed without interference on the part of the attendant. This useful design is now included in lathes and other machines outside the original screw machines. When single castings and forgings are being tooled, automatic feeding of the work is provided with chutes that conduct the pieces to the chuck in which they are gripped.

Automatic control extends to the operation of tools in rapid succession, employing cams. And where these are not used, stops in machine tools of many kinds in turret lathes and elsewhere control the range of movements for traverse, and for diameters. They are used in common lathes, in milling machines, boring machines, and grinders. They avoid the tentative cuts, the method of trial and error, the checking with calipers and rule long before the final dimension is reached, the hesitancy and uncertain movements of the workman, afraid of getting below size.

Arrangements of Tools.—The tool is the central element around which the machine is built, taking the place of human muscle, with incalculable increase in power and efficiency. Relatively few machines now employ a single tool, or one tool with a single cutting edge. Tools are increased in number, and they have many edges as in milling cutters, broaches and grinding wheels. The machine design is radically modified by the nature and extent of the tool equipment. Certain types of tools are employed in particular groups of machines, single-edged in some, multiple-edged in others, but the equipment in the new machines is often very different from that in the older designs. In some cases, half a dozen single-edged tools may be in simultaneous, or in rapid consecutive operation in a machine, the prototype of which employed one tool only. This entails a re-designing of nearly every detail. For not only must the tools have ample support but the driving power must be much greater, and the spindles, bearings and controlling mechanisms must be more substantial. Details must be multiplied in number until in the last designs little remains reminiscent of the older build save the barest outlines—the broad general model on which the later has been grafted and out of which it has grown. Examples are, the lathes with multiple tools, the automatic turning machines, and the lathes with turrets, the planing machines with several tool boxes, and broaching machines that may be regarded as horizontal slotters, but with functions amplified. The same kind of growth is noticeable in the multiple edged tools. Wherever practicable, the aim is to multiply cutters, as in gang milling, in plano-milling machines, several cutters being mounted on a single arbour in the first, and independent cutters on separate heads in the second. And, again, small articles are disposed in series, either lineally, or in circles as in vertical spindle machines. The result in all is an enormous increase in the product, but the machines have to be re-designed. Solutions of the problems that arise are not of a conventional, cut-and-dried character, as was the case with the old models, but each manufacturer specialises round a scheme of his own, comparisons between which are instructive.

Measures for ensuring durability of the machines are of vital importance. Higher elaboration increases cost. Permanent endurance is essential. Many of the old machines left nothing to be desired in this respect. They would last a lifetime. But they were never driven so hard as their successors are, and they contained fewer parts. Larger spindles, and journal bearings larger, and longer, are essential, and more massive castings to carry them, and more rigid framings. Improved lubrication and centralisation of oiling follow. Instead of wasting much time in pouring driblets of oil into a multitude of holes with the chance of missing some, it is distributed through numerous pipes from a common reservoir, often too, to interior stations which are invisible from the outside of the machine. In many cases, as in ball bearings, solid lubricants are used which only require renewal after several weeks. In this way efficiency is secured, and much time is saved.

Materials.—The selection of materials is now a matter of the first importance, for ensuring the durability of a machine. No longer are these taken haphazard. Steels are bought by analysis. Cast-irons are graded by the percentages of the alloying elements. Alloy steels are used to a moderate extent, although their first cost is great, and they are more expensive to machine. After-treatment, tempering, surface hardening is necessary in the case of the steels, and the higher the grade the more carefully must the heat treatment be effected. But the result is durability under the stress of severe and prolonged service.

Manufacture.—The methods of manufacture of machine tools embrace matters that cause much greater anxiety than that of mere interchangeability of parts. They include a minute study of all the components of the design, and of every step, every stage in the building up of the machine. The drawing office is in a large degree under the control of the shops. The details of a new design are not finally stereotyped until the methods of tooling, often entailing small alterations, are finally determined. These things did not count materially in the early days when a firm undertook the manufacture of all the groups of machine tools in existence. Then, the skilled fitter ranked highest in the shop, and numerous corrections ensured the "tight" or "easy" fits, the "full" and "bare" dimensions, often entered on drawings, and obtained by scraping, lapping and other tedious adjustments. All that is of the past.

Later Problems.—A difficulty now is to so design a new or modified machine that it shall appeal and recommend itself, and to produce it, if not cheaply, at the lowest price that is consistent with the elaboration of details now involved. If the machine

does not sell, the venture spells disaster. But so keen are firms to economise in machine production, and to secure high degrees of accuracy that builders of recognised standing and repute can feel confident of results if they supply something that appeals to the requirements of machine tool users. Thousands of pounds may have to be spent in preliminary work, but this is hardly risked if the results secured are substantial. But these must be of unquestionable value. It is idle to think that patching up and tinkering with the old machines of twenty years ago will wheedle prospective purchasers. There are recent features that are now regarded as indispensable in good designs. And if a firm can embody one or more patented features of undoubted value it assures a monopoly of several years, until the machine has realised satisfactory returns. Step by step the scheme of manufacture is developed. Various methods of tooling similar pieces are tested. The time for each is recorded and compared. Carefully schemed jigs and fixtures are prepared. The question of new and specialised machine tools for reducing costs arises, and these may have preference over the standard designs. Route systems follow, and cards of instructions are issued to the machine attendants.

The difference between the manufacture of machines in large and in moderate numbers affects almost every detail of the process. It is the difference between the later and the older methods, each suitable for the carrying through of its product. It is the difference between the work of the assemblers, and the skilled fitters, between the system in which the units of a machine are prepared separately, and assembled, and that in which a charge hand with his mates erects it. If the system suitable for the lesser product and that for the major output were transferred one to the other the result in each would be utter failure and loss. This fact has to be remembered when a shop system or works organisation is being installed, or an existing one changed. The following are the leading characteristics of each system.

Small Products.—When an output is small, the assistance that can be derived from elaborated fixtures and jigs is neutralised by their cost, which bears too great a relation to the numbers of pieces tooled. The aids employed are as of old, the templets for lining off, and the plain drilling templets, methods that are cheap and economical if only a dozen or 20 articles are required, methods that are retained for all large castings and forgings of all kinds, save only those which are repeated frequently in the same machine. Associated with these is the method of marking off for large pieces. The lining-off of the leading dimensions is supplemented by the use of templets for setting out related parts, holes chiefly, and of drilling templets of the simplest kind for holes, the centres of which are related, as where the shafts of gears must be more nearly accurate than can be ensured by drilling or boring to circles lined off merely. If a hole is not started centrally, after-correction is troublesome.

Jigs.—While the outlay that is justifiable on these may be problematical in some cases, yet there are many instances when aids of this kind are necessary in order to ensure the accurate fitting and working of related parts. But the error that may arise is that due to unnecessary elaboration, the employment of details which while essential for a large product can be omitted when it is small. Those which can be simplified are provisions which reduce the time of the attendant in setting and fixing, designs of quick-acting clamps, and those which make for endurance as hardened steel bushings, and slip bushings ground to dimensions, which need not be included in the simpler jigs for small products.

Tolerances.—These are numerous, and fine measurements are included in portions of high-class machines. But they are costly, since they involve more careful setting of tools, and machines, and additional expense for gauging and inspection. The old system recognised a running fit and a tight fit simply, leaving to the fitter the responsibility of making sub-adjustments when necessary, the amounts being determined by his own experience of how much was necessary or desirable. More clearance was allowed in some parts than in others, and the scrape permitted of making the minute differences that ensured the class of running fit desirable. But this is not permissible in the larger output of a standardised article made in the specialising shops. The exact amount of tolerance allowed for each detail is stated, and the parts must be tooled to that, and checked with their own particular sets of gauges before the work is allowed to leave the machine department for the assemblers. A special class of men, the inspectors, is necessary, but the foreman in the general shop is able to check the parts before they leave his department. When corrections are made with the scrape, the bearing is enlarged leaving the shaft journal untouched. But when gauged tolerances are stated, it is better to make the hole the basis, since this is produced with tools that are mostly non-adjustable, such as drills, and the solid reamers.

Interchangeability.—This is not to be confounded with efficiency, since this is equally well secured in single constructions, fitted without relation to any other machine of the same kind. But it is essential in the manufacture of large products, and for the supply of replace parts. The question of tolerances is identified with this, and with each increase in refinement the expense of tooling increases. But this can often be countered by the substitution of one method for another, as that of grinding for work done in the lathe, boring machine, or planer, or milling instead of using single-edged tools. And generally, economy is favoured by reducing tolerances; this can be done in many parts that are not mutually fitting, or which need not fit very closely, reserving the higher limits for certain spindles and slides where practically no latitude is permissible.

Machine Tool Installations.—A recurring question is that of the best equipment of machine tools for the work of manufacture, whether the standard tools shall be employed or those of a more or less specialised character. The latter form a very large percentage in the shops where mass production is adopted. But they are out of place when the output is small, or moderate in volume. This does not say that no specialised machines should be installed, but only that their numbers must needs be very limited. If the conventional views that dominate some unprogressive shops regarding the necessity of putting certain classes of work on certain machines should be abandoned, much real economy is possible by utilising machines for functions that are not regarded as properly belonging to them. Thus, a large volume of work is done in the vertical drilling and boring machines that was formerly regarded as lying exclusively within the province of the lathe. Much of the work once claimed by the slotting machines goes to the key-setting or broaching machines, with extended capacities. The later horizontal boring machines possess great possibilities, not only for their proper work of boring, but for drilling, reaming, milling on a single piece of work without removing it from the table. A stand and turret lathe, equipped either for bar, or chuck work, or for both takes charge of work in small as well as in large quantities, involving many diverse operations, with economies in each. The long stroke planers, and plano-milling machines are suitable for dealing not only with long pieces, but for numerous small articles arranged in tandem, which in the older practice would have been treated singly on the shaper. The plano-miller is for some kinds of work where several faces have to be tooled a more economical machine than the planer, and it is therefore being employed in increasing numbers both in the general and the specialising shops.

Appliances.—There is always some equipment of these in every shop, which if not dignified by the term fixtures, yet are so in fact, since they are set up on machine tables for the accurate location and tooling of a miscellaneous range of articles. These are the angle plates, the machine centres, with or without provisions for dividing, the vee blocks in their many forms and dimensions, the machine vices, the arbours and so on. These elementary forms lead up to the fixtures, in which they reappear in various guises in the specialising shops.

Unit Elements.—At an early stage in machine manufacture the value of the standardisation of certain elements that are often recurring arises. It occurs first in those parts which are most often repeated. Levers are the first to be noticed, then hand wheels, and gears. Minute differences in their dimensions, thicknesses, widths, bosses are eliminated, and thus similar elements are employed not only on one machine, but on several different classes and sizes of machines. Then pieces are drop-forged, and tooled through simple jigs while held in fixtures. They are produced gradually in numbers required not for one machine, but for many, and are stored ready to be charged out as required. As gears occur much more frequently in the later machines than in their predecessors, there are enough of one size apportioned between different machines to permit of cutting and stocking them in considerable numbers. The same is true of their shafts, many of which are splined. From these elements it is but a stage to the standardising of gear-boxes for speeds and feeds, not only for use on one class and size of machine, but for those of other types, and for those which do not differ very widely in capacities. A number of minor elements are similarly standardised in regular dimensions. Screws, bolts, studs, pins, all made in screw machines or turret lathes, are required in large numbers. Variations in dimensions are reduced to the lowest numbers possible, as to the nearest $\frac{1}{8}$ in., or $\frac{1}{16}$ in. If shafts are standardised, so may their bushings be, and ball races suitable for radial or thrust pressures be bought and stored ready for immediate use. So may lubricating pumps, and pipe connections, and speed and feed plates, with the advantage that quick delivery can be guaranteed when orders are secured, and that the preparation of stock can be made during slack interludes, instead of discharging hands.

Shop Drawings.—In the small product shop the drawings are prepared with much less elaboration than those where the work is specialised. These leave absolutely nothing to the judgment or initiative of the men or foremen. Dimensions that are of no consequence in the working of the machine are inserted, as small radii, and unimportant thicknesses. Each element, however minute, has its distinctive number or letter by which it is recorded on the drawing itself or elsewhere. Tolerances are stated, materials, and any particulars that are called for. There is little of this in the drawing made for small manufactures. To elaborate these would increase their expense in too great a proportion to the product.

The foregoing observations illustrate the leading facts that characterise the new era of machine tool manufacture. Specialisation with all that it involves is the direction in which all production is moving. In a few years almost every builder of machine tools will be working on a very limited number of models and sizes, and output and performance may be then even more satisfactory than it is in the advanced shops of the present day.

THE DEVELOPMENT AND MANUFACTURE OF HIGH-TENSILE BRASS AND BRONZE: ERRATUM.—We are informed by the authors of this paper, which was reprinted in our two last issues, that the last sentence in the paragraph relating to mechanical properties, column 1, page 219 *ante*, should have read as follows: "It will be observed also that forging lowers the yield-point of alloy 2 F, but raises the maximum stress; increases both the yield-point and maximum stress of alloy 2 F1, and lowers both the yield-point and maximum stress of alloy 2 F2, although each was treated similarly, and possesses the same Brinell hardness in both the cast and the forged condition."

MINING IN THE MALAY STATES.—The report of the Mines Department of the Federated Malay States for the year 1921 chronicles diminished activity in tin-mining operations. There was a decrease in the acreage alienated for tin-mining, as compared with the year 1920, of 15,800 acres; a decrease in the labour employed in mining of 3,218, or 3·7 per cent.; a decrease of 5,160 horse-power in machinery and hydraulic appliances. The result of the year's working was that the amount of tin exported was 34,490 tons in 1921, as compared with 34,935 tons in 1920, a decrease of only 445 tons. The fact that a drop in the average price of the metal from over 297*l.* a ton in 1920 to 168*l.* a ton in 1921 resulted in a diminution of the exports by less than 500 tons is rather remarkable. There was a decrease in contract labour of 30·7 per cent., and an increase in tribute labour of 49·86 per cent., compared with 1920. The Federated Malay States rely to a considerable extent on tin for their revenue, which has suffered very seriously.

TRANSPORTING APPLIANCES FOR A PRINTING WORKS.

Fig. 1.

Fig. 2.

Fig. 3. SECTIONAL ELEVATION THRO' AA.

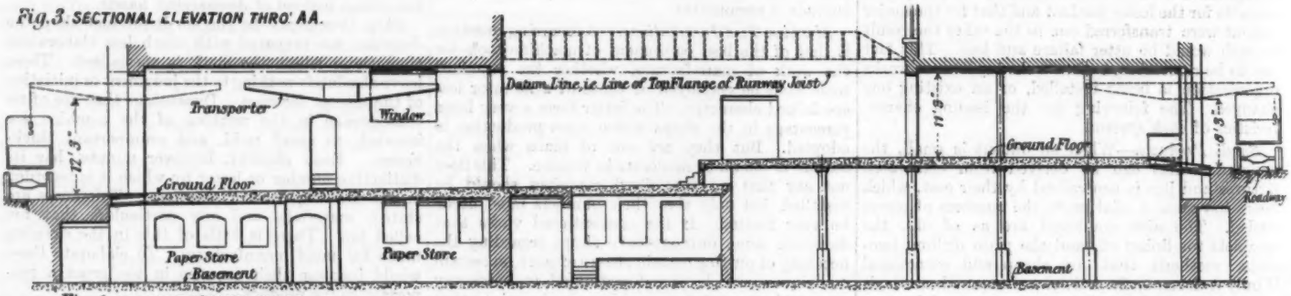
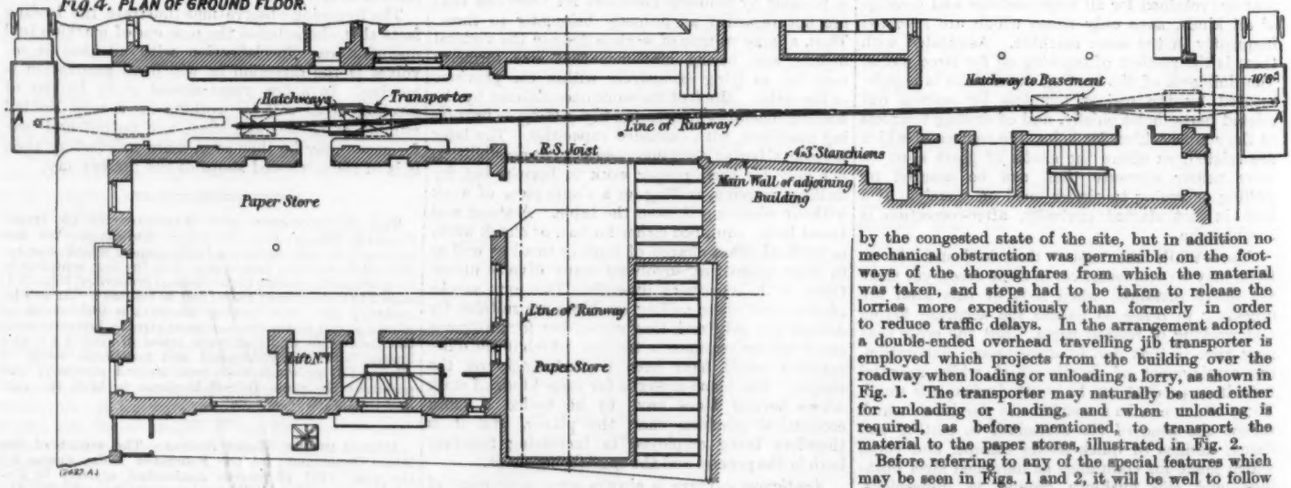


Fig. 4. PLAN OF GROUND FLOOR.

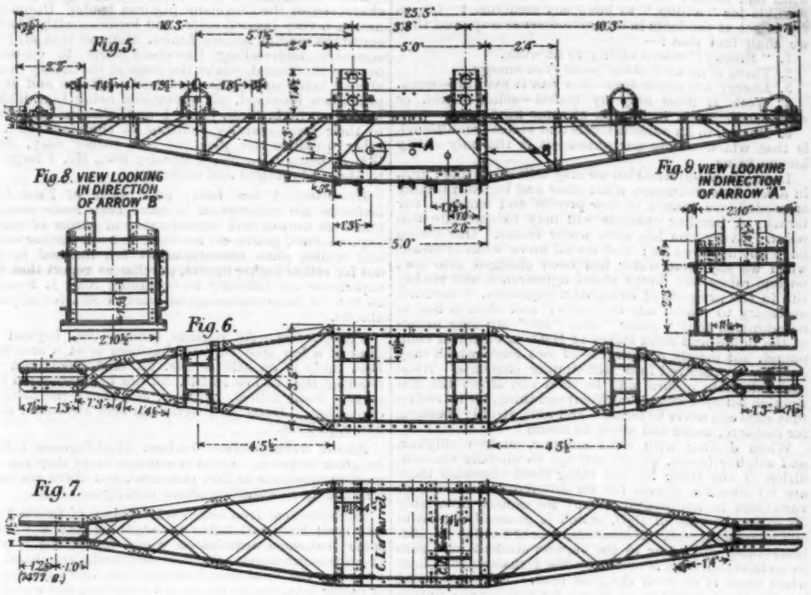


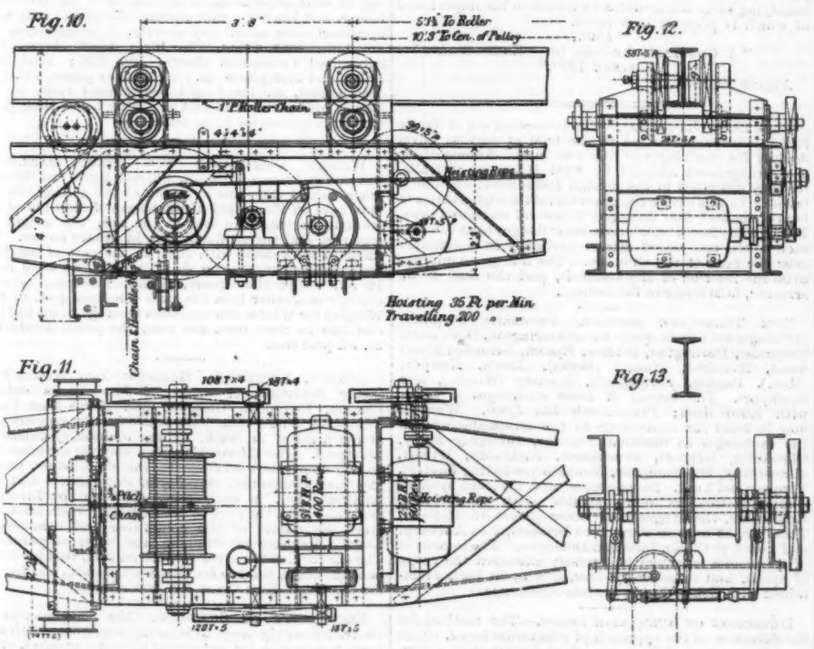
THERE are few mechanical appliances which call for greater individual variation to suit their particular sphere of work than conveyors and transporters, and this is particularly the case when the appliances have to operate in existing buildings. In some cases a more or less standard lay-out will meet the conditions, but in many others special designs and arrangements have to be adopted. An excellent example of a case of this kind is illustrated in the figures on this page and opposite, which show a transporter recently erected at *The Field* printing works in Breams Buildings, Chancery lane, London, E.C. The conditions to be met in this case presented considerable difficulty, but a very neat and practical arrangement has been worked out, and the example well illustrates what can be done with special design even in difficult cases.

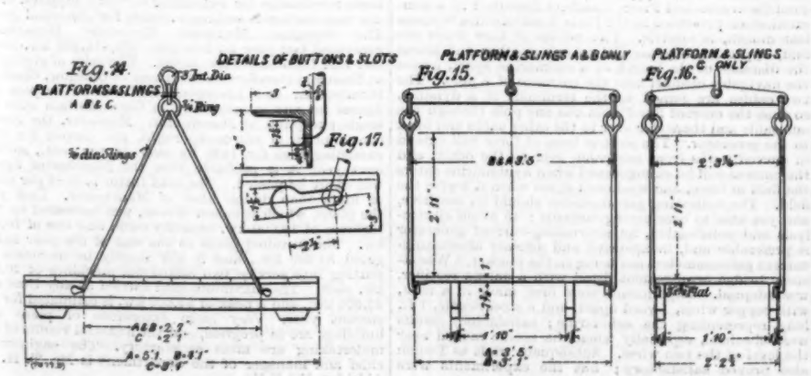
The work required from the transporter is the carrying of reels and flat bundles of paper to the paper stores from lorries or vans standing in the street, or from the paper stores to the printing machines. The transporter is also required to carry printed matter from the machines to the warehouse for binding and packing before dispatch to customers. The equipment forms part of a reconstruction scheme recently carried out in connection with the works. In designing the scheme not only were various conditions imposed by the congested state of the site, but in addition no mechanical obstruction was permissible on the footways of the thoroughfares from which the material was taken, and steps had to be taken to release the lorries more expeditiously than formerly in order to reduce traffic delays. In the arrangement adopted a double-ended overhead travelling jib transporter is employed which projects from the building over the roadway when loading or unloading a lorry, as shown in Fig. 1. The transporter may naturally be used either for unloading or loading, and when unloading is required, as before mentioned, to transport the material to the paper stores, illustrated in Fig. 2.

Before referring to any of the special features which may be seen in Figs. 1 and 2, it will be well to follow through the general lay-out of the scheme somewhat more fully, and for this purpose reference may be made to Figs. 3 and 4, which show respectively a cross-section through, and a plan of, the part of the building with which the transporter is concerned. As will be seen, the works are served by two thoroughfares, Breams Buildings and Cursitor-street, and the transporter is required to serve lorries standing in either roadway. There is a passageway right through the building, joining these two streets, but as will be clear from Fig. 3, this passageway is not all on one level, and there are fairly steep gradients at each end. Material has to be delivered either through one of the hatchways shown in dotted lines, or at various points

ELECTRICALLY-DRIVEN TRANSPORTER.







on the ground floor. The conditions of the situation have been entirely met by the provision of the double-jib transporter, one end of which can be seen in Fig. 1 and which is indicated in outline in Figs. 3 and 4. The reason for adopting a double jib arrangement is the fairly obvious one that while both roadways have to be served the passageway is too narrow to allow of any slewing jib arrangement being adopted.

The double-jib transporter, which runs on the lower web of a single rolled-steel joist, is illustrated in Figs. 5 to 9, while views of the centre portion to a larger scale are given in Figs. 10 to 13. As will be seen from these latter figures there is only one motor for working the hoisting ropes of the two jibs. The two ropes are quite independent, and there are two hoisting drums which are brought into operation by dog-clutches operated by a chain from ground level, as may best be seen in Fig. 13. The arrangement is such that only one drum can engage at a time. The lowering of the load is effected either by the reversal of the motor or by gravity. In the latter case the speed of lowering is controlled by a release arrangement actuated by a hand chain from floor level. An electro-magnetic brake is fitted to the hoisting motion and comes into action when the current is switched off, or on voltage failure. The hoisting drums are fitted with overwind gear which cuts off the current to the hoisting motor when it is tripped. A separate motor is fitted for traversing, as will be seen from the figures. Both motors are controlled from ground level by one man who walks below the transporter and operates it as required. The control chains may clearly be seen in Fig. 1.

The general constructional features of the transporter will be seen in the figures and need not be commented on in detail. Attention may, however, be drawn to the arrangement of the transporter wheels by which it is carried from the lower web of the joist (Fig. 12). As is best shown in Fig. 5 under-running rollers are also fitted to take the upward thrust of the unloaded end of the transporter, as normally only one of the jibs will be carrying a load. Current is supplied at 400 volts and is collected from two trolley wires. The working load of the transporter is 1 ton, and the maximum reach or overhang from the building line when a lorry in the street is being served, is 10 ft. 6 in. The total height of lift, from the basement to the hook, is 25 ft. The hoisting speed is 35 ft. per minute, and the travelling speed 200 ft. per minute. The capacity of the hoisting motor is 3½ b.h.p., and that of the travelling motor 2½ b.h.p. The transporter was built by Messrs. S. H. Heywood & Co., Limited, of Reddish.

As already explained, the transporter delivers its load, either through one of the hatchways or to selected positions at ground level for serving the machines, and in order to facilitate the carrying of the paper, from the place where it is deposited, a series of jack trucks with loose platforms is employed in connection with the scheme. The trucks, of which there are 14 in use, were supplied by Messrs. Hesco, Limited, of Kingsway House, Kingsway, London, W.C. 2., and are of the type to be seen to the left-hand side of Fig. 2. The loose platforms are of special type and are illustrated in detail in Figs. 14 to 17 annexed. A sling consisting of two pairs of swinging links is carried by the transporter. The links fit into slots formed in the angle-iron sides of the platforms and can be coupled or released instantaneously. When on the ground the platforms rest on wood bearers and the jack trucks can be run underneath them. The side frames of the trucks rise when the truck handle is moved to the hauling position, so that the platform is lifted by the truck and may at once be moved to and deposited in any desired position. The operation of loose platform trucks of this kind will be generally familiar, but the additional arrangements for handling the same platforms by the transporter are less usual. There are three sizes of platform in use adapted to the particular sizes of flat paper used in the works. The largest is 5 ft. 1 in. by 3 ft. 5 in., and the smallest 3 ft. 1 in. by 2 ft. 2½ in. There are in all 115 platforms in use, and the system enables a loaded platform to be taken from a lorry in the street direct into the store, or to a printing machine, without any double handling. To facilitate the movement of stock in the paper stores still further and particularly for stacking reel paper an hydraulic-electric portable crane has been installed in the store. This machine, which was supplied by Messrs. J. W. Flower and Co., of Wimborne, is illustrated in Fig. 2. The crane handles the truck platforms in the same way as the transporter, as shown in this figure. For lifting reels of paper a leather or canvas stirrup is used in the case both of the transporter and the crane.

The whole scheme has, in service, proved to be easy to operate, mobile and safe. Some records of the working of the transporter over a period of two weeks may be of interest, but they cannot be taken as indicative of the full value of the plant, since the quantity

of material dealt with is far below the full capacity of the transporter and its accessories. The records are as follows :—

	Week (a)	Week (b)
Paper handled ...	65 t. 18 c. 2 q.	82 t. 1 c. 3 q.
Units used	10·92	13·28
Units per ton handled	0·165	0·162
Cost of current per ton handled	0·42 pence	0·41 pence

The maximum weight of paper handled during any one day was 36 tons 8 cwt., and the minimum 6 tons 13 cwt. 2 qrs. The designs and specifications for the whole scheme were prepared by Mr. Douglas T. Heap, M.Inst.C.E., of 37, Norfolk Street, Strand, W.C. 2, the consulting engineer to the company, and we are indebted to Mr. Heap, and to the Field Press, Limited, for permission to publish this description.

WIRELESS POSITION-FINDING APPARATUS.

Some interesting experiments on wireless position-finding and its application to navigation made by the United States Bureau of Standards, in conjunction with the Bureau of Lighthouses, are dealt with in a publication of the former body, numbered 428. The apparatus installed on the lighthouse tender Tulip, on which many successful experiments have been carried out, comprises a square frame aerial with 4-ft. sides, and having 11 turns of wire, mounted on ball bearings so that it can be turned through a complete circle about a vertical axis. The frame has been installed on the roof of the pilot-house of the ship and connected by means of a vertical shaft to a stirrup carrying a pair of horizontal wires, which serve to indicate the angular position of the frame on a specially-calibrated scale fixed on the edge of the binnacle. Connected to the frame aerial by means of a pair of insulated slip rings on the shaft, is a six-valve receiving set, and to obtain a bearing on any transmitting station, it is only necessary to turn the frame by means of a hand wheel into such a position that the signals heard in a pair of telephones die away. The bearing can then be read on the binnacle scale, and, by taking bearings on other stations, the position of the ship can be fixed with reasonable accuracy.

It should be mentioned that actually there are two positions of minimum signal strength 180 deg. apart, but arrangements are made so that the operator can easily distinguish which of these is correct. For use in connection with this system, permanent transmitting sets have been installed on the Fire Island and Ambrose Channel light vessels, and also at the Sea Girt Light Station on the New Jersey coast. These stations automatically transmit characteristic dot signals on a wave-length of 1,000 m., so that each can easily be identified by an observer unacquainted with the Morse code.

The apparatus on the ship is operated entirely by the navigating officer, which is a distinct advantage in comparison with systems requiring the services of a wireless operator. There is also a considerable saving in time over the system in which a request for bearings has to be transmitted to a land station and the results worked out on shore and re-transmitted to the ship. In foggy weather, when ordinary visual and sound signals are greatly interfered with, the simple and inexpensive means of fixing a ship's position outlined above would appear to be a very useful aid to navigation. The system, and the preliminary work which led to its adoption, is fully described in the publication previously referred to, which is obtainable from the Government Printing Office, Washington, D.C., price 15 cents. The authors are Messrs. F. A. Kolster and F. W. Dunmore.

STATES AND ENTITIES; WHAT IS ENERGY?

To the Editor of Engineering.

Sir,—If any man at an assembly of sane persons ventured to assert that there is no such thing as energy, his friends would probably, on the spur of the moment, think it advisable to have him "certified" when a convenient opportunity occurred; but, on further consideration, it might appear that the poor man was right after all.

The careless use of the four words energy, work, power and force, as if synonymous terms, has led to confusion of thought; and, as was pointed out in one of the monthly reviews some time ago, much of our modern muddle-headedness is due to the mistaking of *states* for *entities*. The following definition is given in the actual words of philosophers, metaphysicians, physicists and compilers of text-books :—

"Energy, regarded as a philosophical 'essence,' assumes many forms, such as light, electric and magnetic effects, chemical action, heat and mechanical work, by which it becomes known to us through our senses. It is of two kinds—kinetic and potential—whose sum total is constant while they change from one to the other, a statement that amounts to the enunciation of a doctrine which is practically the keystone of our modern science and is known as the principle of the conservation of energy. Not until this law was established, and it was shown that energy, like matter, was uncreatable and indestructible, could energy be treated as one of the fundamental physical existences. Its recognition as a *separate entity* distinguishes the present age from all its predecessors; and, now that Planck's theory of 'Quanta' or 'bundles' is accepted by mathematicians, evidence may be expected of the atomic nature of energy or 'action.' Thus it will emerge from the phantom realm of imponderables to take substance—that is to materialise and become endowed with inertia, weight, and structure, manifesting itself in two forms, 'matter' and 'radiation'."

Now, putting aside such questions as Can an age have predecessors, and Why worry about the conservation of what can neither be created not destroyed, how is it possible for "ability" to have any structure? Let us try to get at the facts in a common-sense way, and then we shall find that :—

1. "Energy" *means* ability to do work.
2. There is no such *thing* (entity) as energy.
3. Energy has never done—nor can it ever do—work.
4. Work is done only by bodies—solid, liquid, or attenuated—when in motion of some kind.
5. Matter, in its various forms and states (conditions), is that which affects our senses—it is the only entity known to us.

In ordinary conversation we may talk as we like; but, in a scientific discussion when clear and logical thinking is needed, we cannot be too precise and exact in our terms. A familiar example will help to elucidate this point. Every one has seen water freeze. Our senses have not deceived us; and we all know what is meant when we say that water has been changed into ice; no one raises any doubt about appearance and reality till, in the presence of thoughtful engineers, it becomes necessary to reason out the facts; and then it has to be admitted that "water" and "ice" are only names of the liquid and solid states of H_2O—a chemical compound, not merely a mixture—of two gases which may one day be resolved into still simpler elements. What their ultimate nature may be does not affect the distinction between state (condition) and thing, for we realise that *solid* can never be *liquid*; and also, strictly speaking for instance, water can never be steam!

When dealing with solid sulphur, molten sulphur, and sulphur fumes, we are not apt to mistake the condition of the thing for the thing itself—because there are no common names for its different states due to variations in temperature; but we almost invariably do so in the case of H_2O, which is generally plentiful and more often seen. Numerous cases of similar muddle-headedness will occur to the earnest student who tries to understand what is meant by the transference of heat when there is no such thing as heat. The facts being known, there should be no excuse for making any untrue statement by way of explanation or for the sake of satisfying some mathematical expression the importance of which is possibly over-rated.

I am,

"A Constant Reader of 'Engineering' since 1870."

August 22, 1922.

Flue Dust Deposition.—The increasing use of lignite fuel in Germany has led to the trial of various novel devices for catching the fine flue dust. Among these the arrangement adopted by Paul Meissner, of Halle, recently described in the journal *Braunkohle*, has found favour. In this device the gases travel through a series of bars of channel iron arranged in several staggered rows. The channel irons, which have their flanges bent towards each other, are placed almost vertically in a chamber near the base of the chimney. The flue gases impinge upon the interior of the channels, and the dust being arrested, falls down to the bottom.

The Telephone Service.—Automatic telephone exchanges are now in operation at Accrington, Blackburn, Chepstow, Darlington, Dudley, Epsom, Grimsby, Fleetwood, Hereford, Hurley (Berks), Leeds, Newport (Mon.), Paisley, Portsmouth, Ramsey (Hunts.), and Stockport. The largest of these exchanges is Leeds with 9,600 lines; Portsmouth has 5,000. Work is now in hand for converting to the automatic system the exchanges at Sheffield, Dundee, Broughty Ferry, Gloucester, Gosport, Brockhurst, Kirkcaldy, Dysart, Shrewsbury, Southampton, Swansea (including Sketty), Torquay and York. In connection with the trunk systems communication is now possible with Amsterdam, Rotterdam, the Hague and other places in Holland. There are 12 lines to Paris, 3 to Brussels, 2 to Antwerp, and 1 each to Calais, Lille and Boulogne. The invention of telephonic repeaters has greatly extended the range of speed, and satisfactory service was, in fact, maintained with Genoa during the late conference.

Detection of Submarine Boats.—The method for the detection of the approach of submarine boats, which Paul Sacerdote and Pierre Lambert described in a communication presented to the Paris Académie des Sciences last month, is electric. Two cables of bare wires are laid, approximately parallel to one another and about the distance of the length of a submarine apart, across the navigable channel near the entrance of a port. The two cables are joined to the terminals of a dynamo, so that the current flows from the one pole through the one cable and the water over to the other cable and back to the generator. The electric lines of force will extend in curved paths from one cable over to the other, and the current will be strengthened when a submarine enters the field of force, and weakened again when it leaves the field. The indicating galvanometer should be sensitive, and yet able to bear strong currents; to avoid electrolysis and polarisation, an alternating-current generator is preferable and, inexpensive and delicate alternating-current galvanometers not being on the market, a Wheatstone bridge arrangement fitted with a galena rectifier, was adopted. Experiments were first made in a tank, with copper wires, 1 yard apart, and a steel needle, 1 ft. long, representing the submarine; satisfactory results were obtained, especially when the needle moved near the level of the two wires. Subsequent trials at Toulon also proved satisfactory; but the experiments were discontinued after the war.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday

The Cleveland Iron Trade.—Extreme quietness characterises the Cleveland pig-iron trade. Home sales are on a very limited scale, and business with Scotland continues within narrow limits, Midland iron still considerably underselling Cleveland sorts to customers beyond the Tweed, whilst the state of the money market abroad holds up Continental trade. Home and export prices are identical, all quotations being f.o.t. makers' works, or f.o.b. Tees. No. 1 and siliceous iron owing to their great scarcity continue to command 95*s.*, but other qualities are plentiful and rather easy, No. 3 G.M.B. being 87*s.*, No. 4 foundry 86*s.*, No. 4 forge 83*s.* to 84*s.*, and mottled and white 80*s.*

Hematite.—A few fairly good sales of East Coast hematite are understood to have been made recently, but with output still considerably in excess of current requirements, producers are keen to book further orders, and whilst some manufacturers are inclined to hold out for rather higher figures, purchasers report that they experience no difficulty in obtaining Nos. 1, 2 and 3, at 90*s.* for home consumption, and at 89*s.* for shipment abroad.

Foreign Ore.—As regards foreign ore, beyond the sales of a few spot cargoes, business is at a standstill. Best rubio is on sale at 24*s.* 6*d.* c.i.f. Tees, and it is reported that as low as 24*s.* 3*d.* has been accepted for a cargo. Some sellers, however, ask above the foregoing quotations. Good Mediterranean ores are round about 23*s.* c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke is irregular in price. Local consumers state they can buy medium qualities at 26*s.* delivered, but there are sellers who ask up to a shilling above that figure.

Manufactured Iron and Steel.—Values of finished iron and steel have not fallen to anything like the extent some customers anticipated would follow the removal of price restrictions. On Tees-side works are closed this week for the local race holidays, but there are reports of better inquiries in one or two branches, and whilst the general situation is still very unsatisfactory, it is gratifying to hear expressions of opinion that the outlook is better, and the hope that certain idle plants may be in operation once more, very shortly. Common iron bars are 11*l.*; iron rivets, 12*l.* 10*s.*; black sheets, 12*l.*; galvanised corrugated sheets, 16*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.*; steel boiler plates, 12*l.* 10*s.*; steel angles, 8*l.* 10*s.*; and heavy steel rails, 9*l.* 10*s.* Export orders can be placed at a little below these prices which are quoted for home trade.

Weight Calculator for Steel Bars.—The Cavendish Press of Cheam, Surrey, have just brought out a special slide-rule by which at one setting the user may read off the weight of any length of steel bar of any section, the length in feet to the ton, the weight per foot run, and the sectional area in square inches. The range of sizes dealt with runs, in the case of flat bars, from sections measuring $\frac{1}{16}$ in. × $\frac{1}{8}$ in. up to 3 in. × 12 in., whilst the square, round, hexagon, octagon, triangle and other bars the sizes run from $\frac{1}{4}$ in. to 4 in. Weights for Whitworth nut sizes from $\frac{1}{16}$ in. up to $2\frac{1}{2}$ in. can also be read from the rule, the price of which is 5*s.* 9*d.* post free.

London, Liverpool, Glasgow and North-East Coast Shipping.—A series of four books entitled London, Liverpool, Glasgow, and North-East Coast, "Shipping Who's Who" are issued for the current year at the price of 2*s.* each, by the *Journal of Commerce*, Liverpool. The information they contain includes data on the shipowners and agents, the shipbrokers, marine insurance companies, stevedores, shipbuilders and ship repairers, &c., in each port. The one for Liverpool deals also with the port of Manchester. Each book also gives the names of the committee and members of Lloyd's Register of Shipping and other corporations. The one for London is the seventh edition, that for Liverpool the ninth, the one for Glasgow the sixth, and the one for the North-East Coast the first edition.

Electricity at Shanghai.—The development of electricity supply overseas is hardly appreciated either by those responsible for extending our own supplies, or by our manufacturers seeking markets for electrical goods. The Shanghai Municipal Electricity Department generated last year no less than 226,418,958 kw.-hours, and sold 185,384,748 kw.-hours. The sales of electricity at Shanghai therefore exceed those of Glasgow, Sheffield, Birmingham and Liverpool, and indeed surpass the figures for any municipality in Great Britain with the single exception of Manchester. Moreover, the rise in consumption is extremely rapid, the output for 1921 exceeding that for 1920 by over 28 per cent., so that next year it is probable that the Manchester figures will easily be passed. The load factor is 51·5 per cent., or more than double that of Manchester. Last year the plant, which is steam driven, was increased by two turbines of 18,000-kw. capacity each, and one of 10,000 kw. The installed plant at the end of the year aggregated 84,600 kw., and it will shortly be increased by putting into service two additional machines of 20,000 kw. each. The maximum load carried at any time was 43,554 kw., and a peak of 64,000 kw. is estimated for the current year. Very large extensions of plant and buildings are in progress, and the financial results of the undertaking are most satisfactory. The engineer-in-chief and manager of the department is Mr. T. H. U. Aldridge, M.I.E.E.

NOTES FROM SOUTH YORKSHIRE

SHEFFIELD, Wednesday.

Iron and Steel.—It is difficult to strike an optimistic note with regard to Sheffield industry, though there is every indication that the worst of the slump is past. Unemployment figures, a conclusive evidence of industrial depression, remain about 40,000 actually registered, while to that must be added probably another 10,000 who are not on the Labour Exchange register, being out of work as a result of strikes and other causes which exclude them from the State benefits. Some branches are fairly well booked, and buyers are showing a better disposition to add to their depleted stocks. In other trades, however, notably saws and wire rope, the reverse is the case and business is very flat. The hand-to-mouth policy adopted by the home railways tells against the axle and tyre plant, which is barely running half-time. Some orders have come to hand for locomotive work, largely on foreign account, and this branch will be better employed during the coming winter. A peculiar factor, however, is that orders for railway supplies, both in rolling stock and permanent-way material, are being placed comparatively freely in other parts of the country, while Sheffield for the time being is out of the running. A certain quantity of sub-contracts will doubtless come to the city, but these hardly affect the general situation. The output of iron and steel according to export statistics for July shows a marked increase. The increase in pig-iron produced is 30,000 tons. The home consumption, however, is on a very unsatisfactory level, and the improvement is due chiefly to sales of basic material to the United States and the Continent. The export figures show that a good deal of foreign business is being obtained in the cheapest grades of steel, which has previously gone to Germany, and this is viewed as a hopeful sign. Tool-makers report that orders, while fairly numerous, are of very small account. More business, however, is coming in from the Colonies.

South Yorkshire Coal Trade.—A general improvement is noted in the coal trade of the district. All qualities of coal are moving more freely. Best steam hards show a better demand on both home and export account. An increased tonnage of both cobbles and nuts is going away, although the demand in these qualities is far below the output. Slacks maintain a strong position, with hardening prices. The winter demand for house coal is setting in, and merchants have given notice of an increase in price next month. Cokes, both foundry and furnace, are finding a good market. Prices at the pit are as follows:—Best branch handpicked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 23*s.* to 24*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* to 21*s.* 6*d.*; Derbyshire small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire hards, 19*s.* 6*d.* to 21*s.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—Now that the holiday season is almost completed for another year business is expected to show some expansion. Up till the present, however, there has been little actual movement of any consequence, but foreign buyers are beginning to exhibit more disposition for supplies and export trade all round is getting better. The improvement is slow just at present, but no great boom is really expected. Prices are all tending downwards in most branches of industry, and that is a move in the right direction. Competition amongst producers is becoming keener every day and selling agreements are gradually being scrapped, as all makers are anxious to secure orders sufficient to employ more men and thus reduce present costs. In connection with the latter, wages are coming down also, and already a large portion of the war bonus has disappeared, and in some trades there is a move on foot to take off the remainder. On the whole the general trade outlook is much better, but it will be some time yet before unemployment is reduced to a minimum.

Scottish Steel Trade.—There has been little change in the state of the Scottish steel trade during the past week. With so little doing in the shipyards the demand for plates is reduced to the smallest proportions, but a fair amount of business is passing for sectional material. The lowering of prices recently has failed to induce buyers to place many orders, but makers are hopeful, although consumers are convinced that before long they will be able to do much better. The black sheet makers are doing a shade better, and the new range of prices is responsible for this, as a few more orders have lately been given out. Home consumers are nevertheless none too well provided with business, and improvement must be slow. A fair export trade is passing in plates of light gauge. The current prices are as follow:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 9*l.* per ton; sections, 8*l.* 15*s.* per ton; and sheets, ¼ in., 10*l.* 5*s.* per ton, all delivered Glasgow stations.

Scottish Pig-Iron Trade.—Rather a better tone is prevailing in the pig-iron trade of Scotland, and almost all the present output is being got rid of, with the result that very small stocks are left on hand. If a little improvement shows itself the number of furnaces in blast will be increased very soon. It is not the home trade, however, which is responsible for the consumption of present output as most of it is going foreign, with America one of the best buyers. Hematite is still very quiet, and the bulk of the transactions at present are in good grades of foundry iron. Prices for the latter are firm and the turn stronger at 5*l.* per ton for No. 1, and 4*l.* 15*s.* per ton for No. 3, on trucks at makers' yards. Hematite iron is a shade easier at 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works.

Malleable Iron Trade.—In the West of Scotland malleable iron trade the conditions are almost unchanged. Orders are mainly for the more immediate requirements of users, and most other business is being held back in anticipation of easier prices. When a fall does come several export buyers will be in a position to place a few respectable lines, but the new price, they say, must show an appreciable cut to enable profitable business to be done. For the present the quotation for "crown" bars for the home market is without change at 10*l.* 10*s.* per ton, delivered Glasgow.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Though buying on American and Canadian account has slackened off, enough business has already been placed to keep collieries working for the next month. Indeed free supplies of the better descriptions of large and small coals are scarce, with prices upheld on the basis of 30*s.* for large and 22*s.* 6*d.* for steam smalls. Last week shipments at the various docks amounted to 599,100 tons, which is a record for the present year, and equal to a rate of 30,000,000 per annum, which was the quantity sent abroad in the record year of 1913. Of the total 146,000 tons, equal to 24 per cent. of the total, was sent to the United States and Canada, 65,000 tons going to New York, 44,000 tons to Boston (Mass.), and 10,000 tons to Providence (Rhode Island). Charterings of steamers during the week totalled 33 vessels to carry 200,800 tons, which brings the total since July 17 last to 150 steamers to carry 1,156,000 tons, while another 41 steamers totalling 129,252 net tons were "entered outwards" at the Welsh ports, making a total during the past month of 124 steamers of 300,075 tons, representing a cargo carrying capacity of 780,000 tons. Official returns show that in the seven months ended July 127,294 tons of coal were sent to the United States and Canada from the United Kingdom compared with only 3,103 tons in the corresponding period of a year ago. Shipments to the United States amounted to 67,960 tons, compared with 2,000 tons a year ago, and to Canada to 59,334 tons against 1,103 tons. Of the exports to the United States 42,244 tons, or 62 per cent. of the total, were despatched from the Bristol Channel, as well as 24,049 tons, or 41 per cent. of the amount taken by Canada. The annual report of the Fernhill Collieries, Limited, shows that in the year ended June 30 last a profit of 19,257*l.* was made, compared with 34,608*l.* in the previous year. The dividend on the ordinary shares has been passed for the first time in the history of the company. The Ebbw Vale Steel, Iron and Coal Company, Limited, one of the largest of the South Wales concerns, in their report for the year ended March 31 last show a net loss of 320,870*l.* It is stated that during the year the wages paid by the company amounted to 1,336,195*l.*, compared with 4,168,015*l.* in the previous twelve months.

The Iron and Steel Trades.—The general inquiry for Welsh steel and tin plates is fairly active, but sellers state that selling prices are still unremunerative when compared with the cost of production. For standard boxes of tin plates quotations are from 19*s.* to 19*s.* 4½*d.* In the past week 16,459 tons of iron and steel goods were despatched abroad, compared with 9,335 tons in the previous week. Of last week's shipments black plates totalled 1,140 tons, tin plates 8,156 tons, galvanised sheets 2,393 tons, and iron and steel 4,770 tons.

INDUSTRIAL RESEARCH LABORATORIES, BIRMINGHAM.—The engineer-in-charge, Gas Department, Council House, Birmingham, has issued a card giving particulars of these laboratories, the research work and tests they carry out, together with useful technical data.

THE MINING INSTITUTE OF SCOTLAND.—By the kind permission of Messrs. William Baird and Co., Ltd., the Council of this Institute have been enabled to arrange an excursion for the members to Tofts and Auchincruive Collieries, Prestwick, Ayrshire, on Saturday, September 2. Applications for tickets should be addressed to Mr. G. L. Kerr, Secretary, Royal Technical College, Glasgow.

THE "G.A." SYSTEM OF SHIP CONSTRUCTION.—A booklet illustrating and describing the "G.A." system of ship construction which has been patented by Mr. D. B. Gebbie and Professor T. B. Abell has reached us from the latter. This system, it will be remembered, was foreshadowed in a paper read by Professor Abell at the spring meetings of the Institution of Naval Architects in 1921 and reproduced on page 376 of our 111th volume. Both Lloyd's Register and the British Corporation, we understand, have offered the application of the system to the construction of ships of the highest class, and the principal advantages claimed for it are the saving in structural material and labour costs resulting from its employment. It also gives increased accessibility for inspection and repairs. The illustrations in the booklet which are intended for general guidance, show the application of the system to the construction of the double bottoms of vessels 500 ft., 430 ft. and 265 ft. in length, but the system requires to be adapted to particular or special vessels in accordance with the trade on which the ship is to be employed and to the general arrangement of the rest of the structure. Professor Abell is, of course, Professor of Naval Architecture and Dean of the Faculty of Engineering at the University of Liverpool, and we have no doubt that copies of the book and information relating to the system, can be obtained from him.

NOTICE OF MEETING.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, August 31, at 2.15 p.m. at the Mappin Hall, The University, Sheffield, the Annual General Meeting will be held. The Report of the Council for the year will be read and the Election of Officers will take place. Subsequently two papers will be read and discussed, viz., "Methods of Working the Barnsley Seam of the South Yorkshire Coalfield," by Lieutenant-Colonel H. and Mr. W. Rhodes; "Stainless Steel," by Dr. W. H. Hatfield.

COMPETITION FOR ROYAL SCHOLARSHIPS.—The conditions of competition for Royal Scholarships, and other awards in science for 1923, are now available, and can be obtained from the Board of Education, Whitehall, London, S.W. 1. Candidates may compete in any one of five groups of subjects included under the headings mechanics, physics, chemistry, biology and geology, the examinations in which will be held in or about May next. Applications for admission must, however, be made on the prescribed form (obtainable from the Board) not later than February 1, 1923. Particulars as to the awards to be offered on the result of the competition will be announced later.

ELECTRICITY IN STEPNEY.—The report of the Electricity Supply Department of the Borough of Stepney for the year ending March 31 last shows that over 22,000,000 kw.-hours were sold in the borough during the year, this constituting a record for the undertaking. The rated capacity of the plant was 16,000 kw., and the peak load on the generators was 13,850 kw. The number of units generated was 30,083,800, of which 845,707 kw.-hours were used on the works and 4,822,029 kw.-hours absorbed in transmissive conversion and distribution. The total cost per unit sold was 1·934*d.* and the total income per unit sold was 2·173*d.* The net financial result, for which the engineer and manager, Mr. W. C. P. Tapper, is to be congratulated, is a net surplus of 28,388*l.*, the largest in the history of the undertaking.

PRECAUTIONS AGAINST ACCIDENTS IN MOTOR BOATS.—Recommendations as to the precautions to be taken by builders and users of petrol motor boats, which, for the reason that they do not carry more than 12 passengers, are not periodically examined by the Surveyors of the Board of Trade, have recently been issued by the Mercantile Marine Department of the Board. Among the precautions against fire it is urged that the motor, if placed below deck, should be enclosed in a separate, well-ventilated compartment in which as little as possible of the woodwork should be left exposed. Watertight bulkheads should be fitted to prevent petrol or oil from gaining access to the space occupied by passengers and stores, and the petrol tank should be of sufficient capacity to obviate the necessity for carrying a supply in spare cans. Several suggestions as to the design and arrangement of the petrol tank and fittings are made, and it is further pointed out that exhaust pipes should be efficiently cooled and that means for extinguishing fires from petrol should be carried. The use of paraffin as fuel, in place of petrol, is recommended wherever possible. With regard to life-saving appliances the Board do not consider life jackets so suitable for small launches as buoyant deck seats and lifebuoys, and they recommend that at least two of the last-mentioned appliances should be included in the life-saving equipment, which should be of sufficient capacity for all persons on board; for this purpose a lifebuoy is reckoned as buoyancy for two persons. In conclusion, it is pointed out that very serious responsibility will be incurred by those concerned should an accident involving loss of life occur through failure to take reasonable precautions.

THE "TELETYPE" TELEGRAPH PRINTER.—A novel and interesting type of telegraph printer for use on long or short lines where the traffic does not necessitate an operating speed exceeding 45 words a minute, has been introduced into this country by Mr. Donald Murray, of the Murray Printing Telegraph Systems, 55, Goswell-road, E.C. 1. The machine, which is made by the Morkrum Company, of Chicago, is about the size of an ordinary typewriter, and is provided with a universal keyboard and a printing device which is an ingenious combination of the Hughes and Baudot printers. Depression of any one of the keys sets up a series of from one to five electrical impulses in the line, the number and sequence of the impulses differing for each character in accordance with the well-known "five unit" code. These impulses operate the printing mechanism of an exactly similar machine at the other end of the line and the letter corresponding to the key depressed is printed in plain Roman type on a paper strip. The printing mechanism of the sending machine is operated simultaneously so that a record of the message is also kept at the sending end. The mechanism of each machine is driven by a small electric motor, both of which must be run at approximately the same speed, although synchronism is not necessary. A centrifugal governor is fitted on the motor shaft to keep the speed constant, and a simple stroboscopic device is employed for adjusting the speed when starting up. The machine, which can be operated by any typist, would appear to be well adapted for connecting sub-offices and large customers with the head offices of telegraph administrations, as well as for railway telegraph work. It can also be used for intercommunication in large stores and business houses, having several advantages over the telephone for this class of work, especially for the transmission of figures. Another advantage is that the message is recorded at the receiving end whether anyone is in attendance or not.

THE RIACHUELO TRANSPORTER BRIDGE, BUENOS AIRES.

(*For Description, see Page 227.*)

Fig. 50. Top Girder Erected at the Builders' Works.

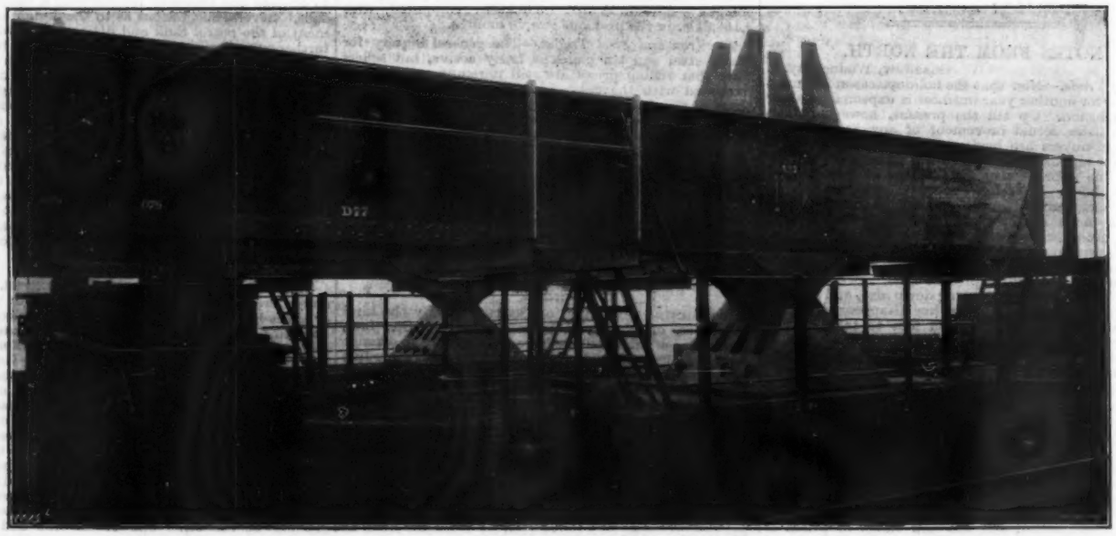


Fig. 51. Fixed Bearings and Part of Bottom Booms of Top Girder.

The Water Power of Finland.—Although Finland is rightly known as the country of lakes, about a tenth of the whole area being under water, the plateau character is not favourable to a wide distribution of water-power. Apart from the coastal districts the general level lies between 70 m. and 80 m. above the sea, and the available water-power is concentrated in a small number of rapids. Three main water systems may be distinguished. The largest eastern basin, as large as the two others together, has its centre in the Lake Saimaa which empties through the Wuoksen river into Lake Ladoga in Russia. The total fall in this river, 71 m., is utilised only to a small extent, 14,000 h.p. out of about 400,000 h.p. in the famous Imatra rapids, but the Government is now contemplating to make 100,000 h.p. available for the railway service. The second, the central basin, discharges its water through the Kymmene river into the Gulf of Finland; the head of 72 m. would make about 200,000 h.p. available, one eighth of which is now utilised. The outlet of the third western basin is the Kumo river, which flows into the Gulf of Bothnia; some 20,000 h.p. out of 120,000 h.p. available are utilised, but projects for further hydraulic power stations are ready. Apart from these river systems there are several more isolated rivers of which the Ulea and the Kemi are the most important. Both these rivers flow into the northern part of the Gulf of Bothnia. The Ulea river and lake might, with their 122 m. head of water, yield 275,000 h.p. The Kemi river, draining Finnish Lapland, the northern part of the State, has a catchment basin nearly as large as the Wuoksen, and a fall of 147 m. in a length of 240 km., but it lacks convenient lake reservoirs, and the possible 460,000 h.p. are hardly utilised so far. The other rivers either flow east through Russia into the White Sea or directly into the Arctic Ocean; to the latter system belongs the Pasvik river which discharges the waters of the Enare lake and forms the frontier between Norway and Finland; there are 125,000 h.p. available, part of which would be claimed by Norway. These north eastern water courses may become important with the development of the railway system. At present the Hydrographic Bureau of Finland estimates the whole available water power of the country at 2,500,000 h.p.; this figure, however, might probably be considerably raised by judicious regularisation.

THE RIACHUELO TRANSPORTER

(For Description, see Page

Fig. 23. ELEVATION OF GIRDER.

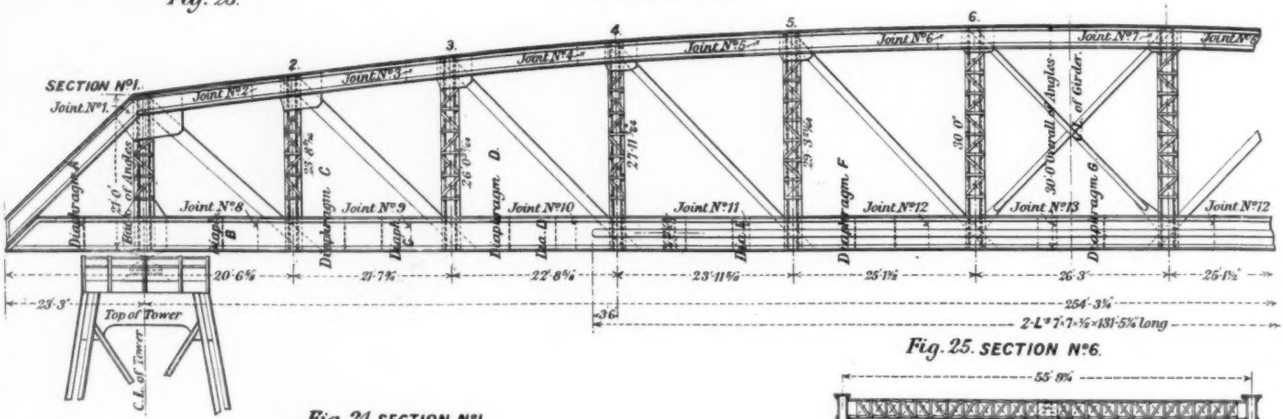


Fig. 24 SECTION N°1.

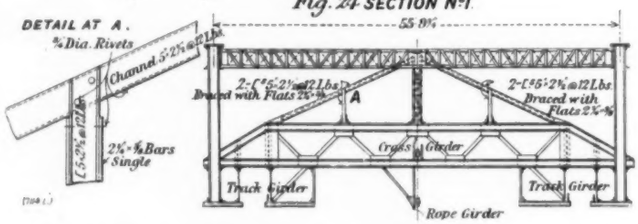


Fig. 25. SECTION N°6.

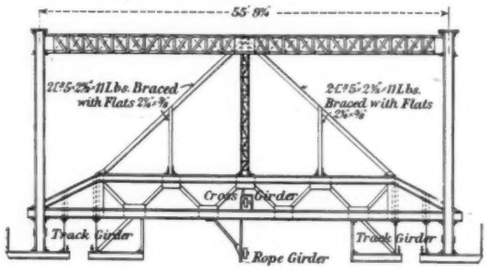


Fig. 26.

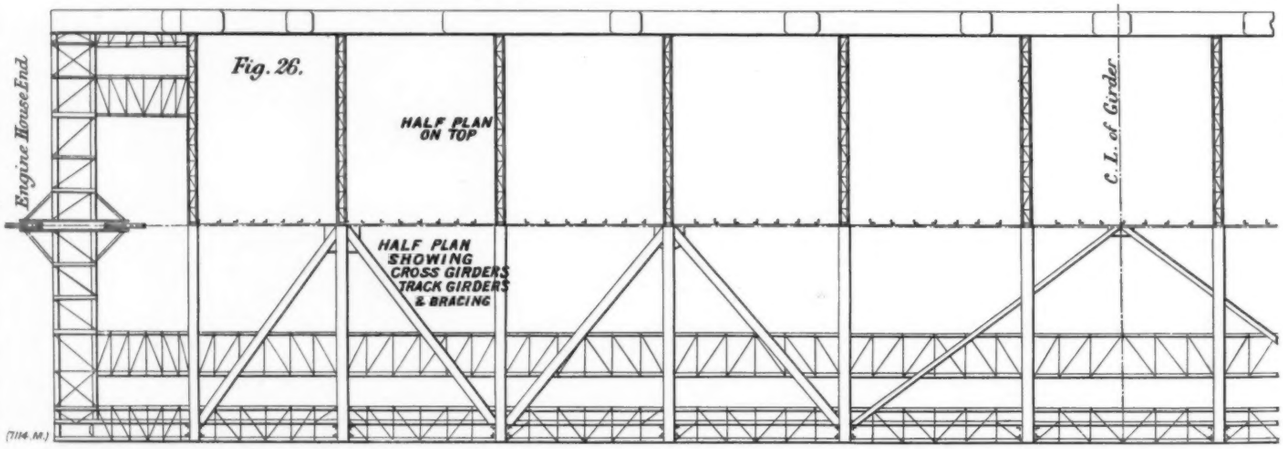


Fig. 35. ELEVATION OF BOTTOM BOOM.

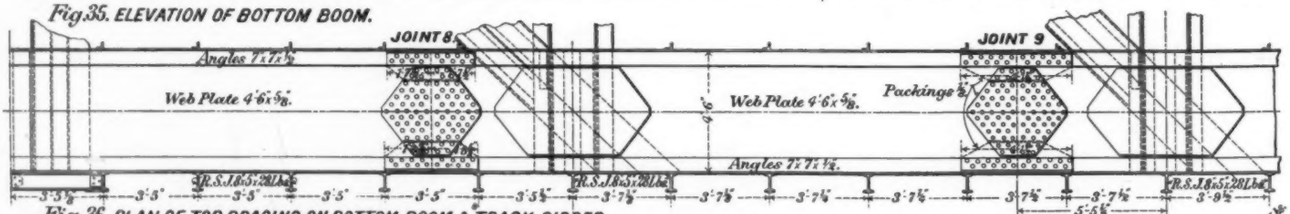


Fig. 36. PLAN OF TOP BRACING ON BOTTOM BOOM & TRACK GIRDER.

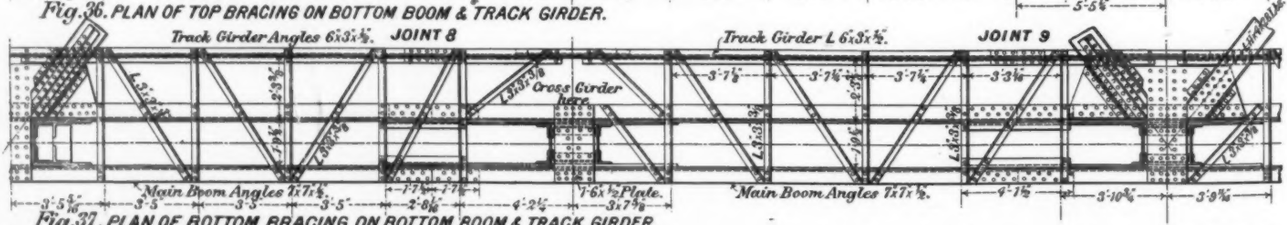


Fig. 37. PLAN OF BOTTOM BRACING ON BOTTOM BOOM & TRACK GIRDER.

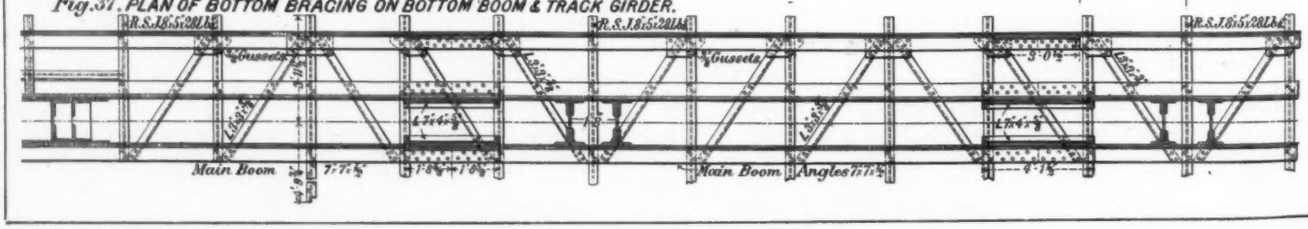


Fig. 27.

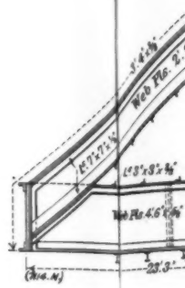


Fig. 28.

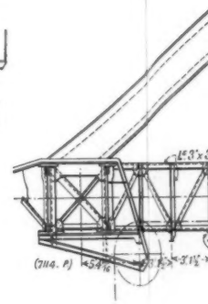
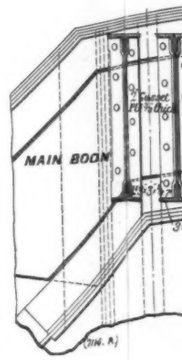


Fig. 32. SECTION O... BRA...



ORTER BRIDGE, BUENOS AIRES.

(Description, see Page 227.)

Fig. 27.

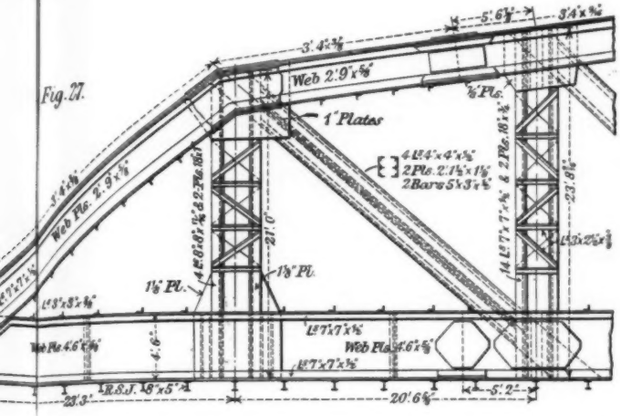


Fig. 28.

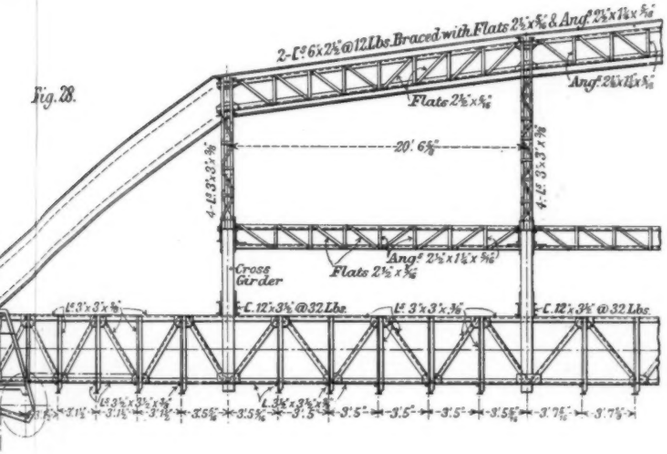
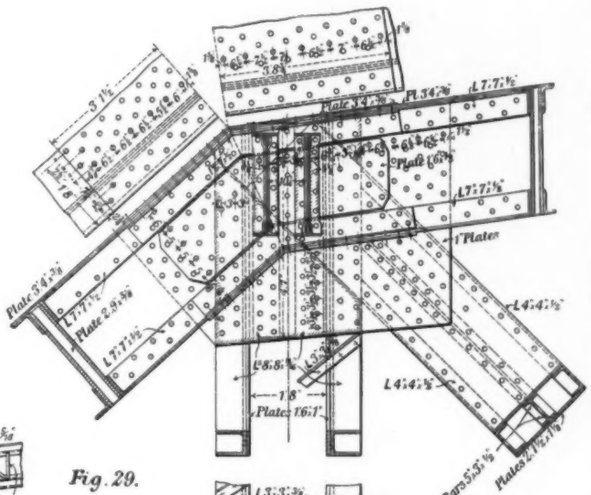


Fig. 29.



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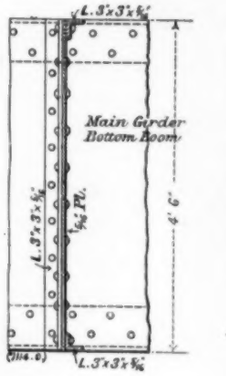

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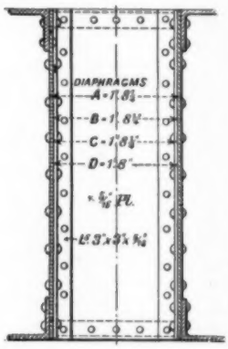

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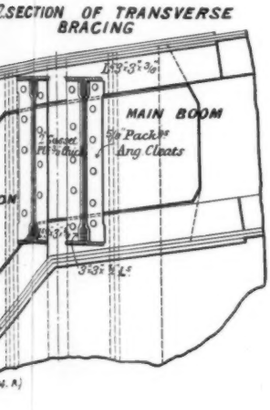

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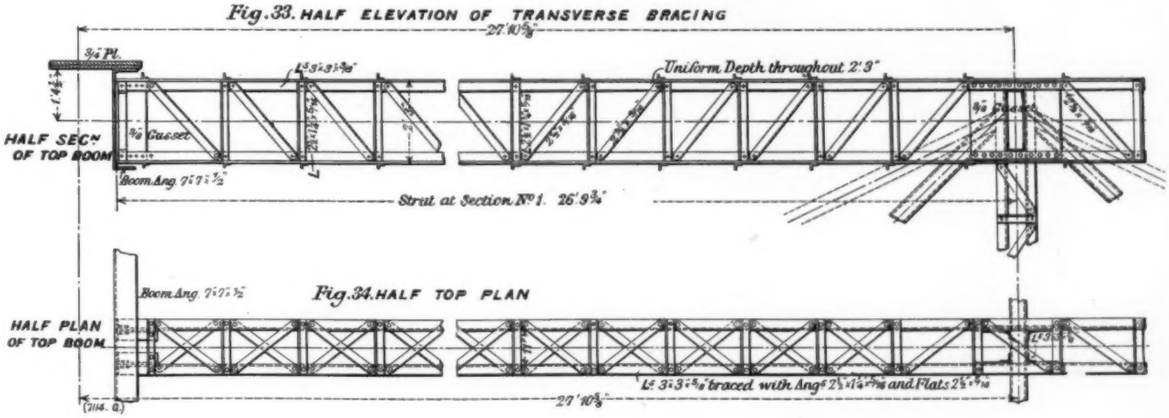
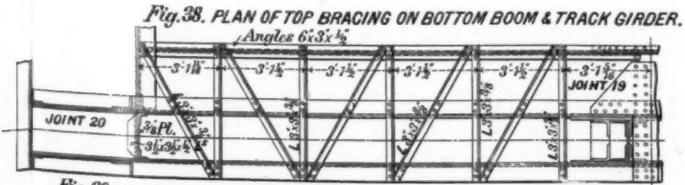


Fig. 34. HALF TOP PLAN

Fig. 38. PLAN OF TOP BRACING ON BOTTOM BOOM & TRACK GIRDER.



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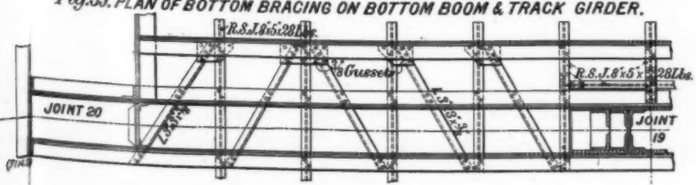

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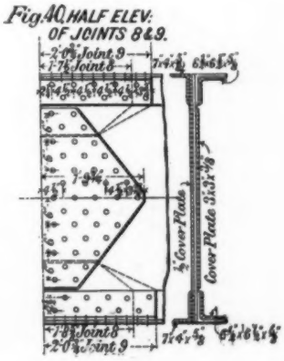
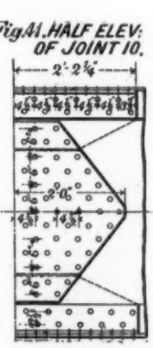


Fig. 41. HALF ELEV: OF JOINT 10.



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ENGINEERING.

FRIDAY, AUGUST 25, 1922.

THE COMMERCIAL VALUE OF KNOWLEDGE.

IT is possible to discuss the commercial value of knowledge without for a moment assenting to the narrow view of those who regard all knowledge as valueless except such as ministers to the comforts of man. Even the commonly heard defence of apparently useless investigations on the ground that the knowledge so gained may ultimately be turned to account is really a surrender to the purely utilitarian idea. A truer contention is that the pursuit of knowledge of any kind is justified by the intellectual pleasure it affords, and if the pursuit results in discoveries which can be turned to material advantage a double end is gained. It is nevertheless the fact that most knowledge is sought from strictly utilitarian motives. The curriculum of the ordinary school or college is arranged primarily to fit youths to earn their own living, and subjects which do not directly further this aim, no matter how valuable they may be in promoting culture and good citizenship, are often barely tolerated even if taught at all. Education is directed along lines devised to equip the young man with the particular kind of knowledge which will be useful to him in his future career, and when he passes his final examination or takes his degree he expects to find the world ready to afford him a livelihood in return for the knowledge he has acquired.

Lads destined for the engineering profession frequently suffer a profound disillusionment when they first seek to enter practical life. The certificates and diplomas which they thought would cause them to be welcomed in industrial establishments do not have this effect. Nobody seems to want them on account of the knowledge they have so laboriously acquired, and they suffer the further sting of noticing that men who could hardly solve a simple equation are holding positions of power and responsibility. Faced with this situation they are apt to rail against employers as being stupidly conservative and blind to their own interests. Such an attitude is, of course, absurd. The average engineering employer is a very shrewd man with a fine appreciation of value whether in men or things. Were he otherwise he could not run his business successfully. It is therefore somewhat presumptuous on the part of inexperience to believe that a different kind of management would secure greater success, although self-assurance is recognised as the prerogative of youth. It would be more to the point, indeed, if the scientific training was applied to a short study of the causes for the lack of appreciation with which employers regard the credentials of so many applicants. This would furnish much food for thought, and the facts which would emerge might even have a beneficial influence upon the training of young engineers in general.

The first thing to be realised both by students and their teachers is that employers are the sole judges of the kind of youths they want. It is no good contesting this fact, and it is fatal to ignore it. However strongly our professors may feel that the particular kind of training which they give is the best possible basis for an engineering career, and however confident the recipients of this training may feel in their own merits, it is the employers' valuation alone which counts. Things might be different in a better world, but so long as we have to accommodate ourselves to "this sorry scheme of things entire" so long will this fact dominate the situation. This being conceded, the next step is to consider what kind of knowledge the employer looks for in an applicant for employment. The answer to this question will appear somewhat startling to those who do not realise what passes through the mind of a man when he is deciding on the merits of a candidate. It is nevertheless true that both the nature and extent of the academic qualifications of the applicant exert, in general, a very minor influence upon the chances of his engagement. Assuming a reasonable education, it is character, intelligence, and willingness to work and to learn which are really valued. Knowledge, in the sense of book-learning, is given very little weight except as an indication of industry and ambition. Without character, intelligence and energy, all the book-learning in the world will not make an engineer.

In thus pointing out what every works manager knows to be true, we particularly do not wish to be accused of depreciating the value of knowledge. The real reason why it is often supposed that knowledge should have a higher commercial value than it has, is because of a confusion of thought. The employer, as must be admitted if any reflection is given to the subject, does not pay a man for what he knows but for what he can do. Similarly he engages a youth solely with regard to what he anticipates the youth will render himself capable of doing in a reasonable time. Knowledge is a purely personal possession of the man who has it and, strictly speaking, its value is to him and to nobody else. The mental gratification it causes is obviously personal, and if the knowledge is of a nature to assist his actions, it is these that are paid for by his employer and not the knowledge behind them. A man who knew everything would be unemployable unless he could do something. He would be as much use, and no more, than a row of books. Knowledge, therefore, only has any commercial value in so far as it is combined with the ability to produce something useful, and the demand for the thing produced is ultimately the measure of the monetary value of the knowledge needed for its production.

This is the truth which is forced into the minds of so many young men by their first experience of practical life, and which is the cause of so much disappointment that might have been avoided had a more accurate view of commercial needs been presented to them. Hundreds of youths are turned out every year who can determine the stresses in rotating solids, calculate critical speeds, and "design" alternators, masonry dams, turbines, and what-not. But the market for such ability is always quite small, and in any case the responsibility for the design of anything really important would never be entrusted to a man whose judgment was not matured by lengthy experience. There are more points to be taken into consideration by a designer than can ever be expressed in formulæ or learned outside the school of practical experience, and it is the attention given to these which differentiates good design from bad. The view held by firms as to the qualifications of a designer are clearly shown by the wording of advertisements for such men. One never finds a request to "state academic distinctions," whereas "state experience" is about the commonest injunction met with.

There is nothing to be gained, as we have indicated

already, by saying that employers would find it much more advantageous to employ young men straight from college upon important work. Employers must be allowed to understand their own business and their views on the matter have to be reckoned with, as they have the most effective means possible of enforcing them. Furthermore, supposing for example that every turbine-designer's job which fell vacant in a year were given to some young man leaving college, the appointments would be so few that there would be a small army of men left over, all possessing equal qualifications for the posts. It is perfectly certain that every year our colleges turn out a far greater number of men with an advanced theoretical knowledge of design, than can ever hope to find employment for the particular kind of learning they have acquired. In due course most of them get absorbed into engineering work of one kind or another, but their start has been a bad one, and both their age and outlook are such that many will never get any adequate practical workshop experience at all. Engineering knowledge does not grow from the top downwards, any more than a tree does, and the fruits will not be worth much unless the roots are sound. The studies which should be the finishing touches to an engineering education, and which cannot usefully be undertaken except by those with sufficient practical knowledge of machinery and workshops, to realise the real conditions of a problem, are too often entered upon without any such experience whatever. The result is never satisfactory, and frequently leads to the preparation of designs which unfortunately antagonise employers against college training generally.

A great deal of harm in connection with engineering education arises from a false analogy being drawn between engineering and certain other important professions. If a boy is to become a doctor, a barrister, or a solicitor, he undergoes a definite standardised training, and on passing certain examinations, is regarded as being qualified to practise. He is protected by law against competition from other men, however skilful they may be, who have not had the standard training, and he is therefore reasonably sure of a decent livelihood. Whether such a state of affairs with regard to the engineering profession would be desirable or otherwise need not be discussed. Engineering differs from the other professions named in the fact that each of the latter is restricted to a certain definite field. The lawyer has to be conversant with the laws of England, and for all practical purposes his profession begins and ends with them. The doctor restricts himself to matters concerning the human body, and complex as this is, the ground may be reasonably well covered by a suitable course of education, and the proficiency of the student certified before he is let loose on the world. No conceivable course of education could make a man proficient in even a fraction of the duties which may fall to the lot of the engineer. Diplomas certifying his knowledge of certain subjects have not the same value as those in the other professions, because in engineering the range of a man's possible duties is so wide. Moreover, the possession of them does not place him in a privileged position with regard to equally competent men who may be without them. Engineering partakes much more of the nature of a constructive art than of a science, and the knowledge which has the greatest commercial value is that skill which enables a man to make or do something which the world needs.

THE IMMURED COPIES OF THE IMPERIAL STANDARDS.

No one who has ever been responsible for any work of high precision will need to be reminded of the vital importance of maintaining standards of reference of unquestionable accuracy. To engineers in particular, therefore, a ceremony which took place recently in the House of Commons will be of special interest. Upon August 3, in the presence of the Speaker and a number of Members of Parliament, as well as several official representatives of the Departments concerned, the copies of the Imperial Standard Yard and Pound, which are immured in a recess upon the landing of the staircase leading up from the lower waiting hall, were formally returned to their position and walled up, after they had been carefully verified against the primary standards and their other legal copies.

The history of the present standards dates back to the fire which destroyed the Houses of Parliament in 1834, when the legal standards, which were in the custody of the Clerk of the House, were lost, after an existence, as standards, of only ten years, although they had actually been constructed long previously. A strong scientific committee was appointed in 1838 to consider the best means for replacing them. Legal provision had, indeed, been made in 1824, as to the basis upon which reconstruction was to be carried out, should it ever become necessary. It was then enacted that the yard should be re-determined, from the fact that the length of a pendulum beating seconds of mean time, when swung in a vacuum at sea level, in the latitude of London, was 39·1393 in. Similarly, the pound was to be founded upon the determination that the weight of 1 cub. in. of distilled water, taken against brass weights, and in air under certain specified conditions, was 252·458 grains.

Both of these determinations are of a character involving serious experimental difficulties, and the results which had led to the figures laid down were themselves open to suspicion. The new standards were, therefore, ultimately based upon existing unofficial standards, which had themselves been recently compared with the lost standards, as it was considered that less uncertainty was thereby involved. The necessary work was carried out by scientists of the very first rank, with an accuracy not very far short of what can be obtained to-day. The preliminary work upon the yard was done by Baily, and after his death, the actual verifications were performed by Sheepshanks. He also, unfortunately, died just as his work was completed, so that the account given in the Philosophical Transactions for 1857 appears under the name of Airy, Astronomer Royal and Chairman of the Standards Commission. The new standard pound was reconstructed and verified by Miller.

At the same time as the Primary Standards a number of copies were also constructed and verified. The yard bars being of a special bronze alloy selected by Baily, and still known as Baily's metal (copper, 16 parts; tin, 2½; zinc, 1), were relatively cheap. Quite a large number were cast and inter-compared over a period of some years, so as to ascertain, in some measure, whether they were likely to be permanent. They were then widely distributed, several being sent to foreign Governments and to the Colonies. The pound, however, was of platinum and naturally expensive. Only four copies were therefore made in that material, but a number of gilt-bronze pounds were made and verified for distribution.

Four of the yard bars and the four platinum pounds were given special status, one of each being deposited at the Royal Mint and the Royal Observatory at Greenwich, and with the Royal Society. The fourth set was immured in the structure of the Houses of Parliament, the Commission recommending that it should only be disturbed under the direct sanction of an Act of Parliament. In this way, should either of the Primary Standards be lost or damaged, restoration from its copies would not be difficult. At a later date a further set was provided for the use of the Board of Trade, so that the "Parliamentary copies" of the yard and pound are now five in number.

Each of the standard yards is a bronze bar, 1 in. square in section, and 38 in. long. At 1 in. from each end a circular well is drilled to half the depth of the bar. In the bottom of this well there is a smaller hole, into which a gold plug is inserted, and finished off flush with the bottom surface of the well. The plug bears two longitudinal and three transverse incised lines. The standard length of 1 yard is defined as the distance between the central transverse lines upon the two plugs, taken at a point midway between the longitudinal lines, when the bar is at a temperature of 62 deg. of Fahrenheit's thermometer, and supported upon bronze rollers in such a way as best to avoid flexure. The definition does not specify the number of rollers to be used, but all the standard bars were placed in their boxes resting upon a lever frame bearing eight such rollers, so arranged that each of them bears its due proportion of the weight of the bar. They support the bar at what are now known as the "Airy points," which are spaced from each other by a distance of $l/\sqrt{n^2-1}$, where l is the length of the bar and n the number of points of support.

The object of sinking the wells was, of course, to bring the defining lines as closely as possible upon the neutral axis of the bar, so as to eliminate still further any possible effect of flexure upon the reading of the length. How effectively this object was attained may be seen from the results of one of Sheepshanks's experiments, when, supporting one of his bars first at the Airy points, and next at its two ends, he observed an apparent difference in length, under these extreme conditions, of no more than two millionths of an inch.

The Imperial Standard Pound is in the form of a cylinder of platinum, about 1·35 in. high and 1·15 in. in diameter, and has a groove run round it near the top to facilitate the use of an ivory fork for lifting it. It is of course a pound avoirdupois, of 7,000 grains, whereas the lost standard was a pound troy, of 5,760 grains. In his reconstruction, Professor W. H. Miller had recourse to two platinum pounds, both of which had been carefully compared with the former standard under conditions of temperature and pressure which had been carefully noted. One of these two weights was the property of the Royal Society, and is still in their possession. The other belonged to Schumacher, who performed the comparisons referred to. There were also accessible to Miller a number of brass pounds, some of them being replicas of the lost standard, which had been tested against it at various times. Upon comparing these brass pounds with each other, Miller found his results so different from those previously obtained, that he decided to reject them altogether and to rely wholly upon the two platinum pounds, which appeared to have undergone no change. A serious difficulty arose, however, from the fact that no determination of the specific gravity of the old standard had ever been recorded.

Hitherto, the standard of weight had been merely a commercial one, and all weighings had been carried out in air, without any corrections being applied. It was now to become an accurate and scientific one, and it was therefore necessary to eliminate the varying effect of the buoyancy of the air upon it, by reducing all weighings to vacuum. The weight of the lost pound in air was accurately known from the two platinum pounds available, but since its specific gravity was not known, it was impossible to determine what allowance to make for the buoyancy of the air, so as to reduce this result to vacuum. The best Miller could do was to assume that it had the same density as one of its supposed copies, to which it appeared to correspond most closely in its dimensions, as recorded upon a drawing made some years before. The new standard was therefore adjusted as nearly as possible so that a brass weight of this assumed density, which exactly balanced the new primary standard in vacuum, would in ordinary air exceed the old standard in the ratio of 7,000 to 5,760, this being the ratio between an avoirdupois pound and a troy pound.

This brass commercial pound is the link between the old standard and the new one. It maintains proportionate equality with the lost pound in air, and equality with the new standard in vacuum. The difference between the commercial pound and the platinum pound in air, amounting to about two-thirds of a grain, is equal to the difference of the buoyancy effect of the air upon the two, as determined from the known volume of the platinum, and that corresponding to the assumed density of the old standard.

The new standards were legalised in 1855, but the recommendation of the Commission as to the inviolability of the immured copies was not adopted. Since the date of their original deposit, however, they have, in fact, very rarely been disturbed. Once, in 1864—when the condition of the primary standards caused some concern as to the possible state of preservation of the copies—they were removed and examined, and replaced after packing with a little more precaution. In 1870, as the wall within which they were then enclosed was being demolished, they were taken out, to be placed in

1872 in their present position, but upon that occasion they were not examined.

Although legal provision had been made for the periodical comparisons of the primary standards and their other copies, the immured copies were explicitly excepted. Hence it arises that the first time that they were re-verified after their original construction, was in 1892, when Mr. Chaney, Superintendent of the Standards Department, compared them with the Board of Trade copies, in the House itself, taking the necessary apparatus there. Clearly, no great accuracy could be expected under these conditions.

From that date until the present year, a period of thirty years, they were not again taken out. It is not quite clear what was originally in the minds of the members of the Standards Commission, when they suggested that the immured standards should remain untouched, for if these copies are to be of real use as such, it is important that their errors should be ascertained at intervals.

This year marks the end of a ten-year period, when under statute the Parliamentary copies have to be compared with each other (always excepting the immured copies). It was decided this year to carry out a complete inter-comparison of the primary standards, *all* the Parliamentary copies if possible, and also other reference standards belonging to the Standards Department and the National Physical Laboratory. The requisite permission having been secured, early in June the stone slab closing the front of the recess in which the standards are deposited was removed, and the standards taken out and inspected, in the presence of the Speaker.

The yard bar showed a little discoloration, possibly electrolytic in origin, where it had been resting upon its rollers, which were not of the same alloy as the bar. Some rubbing also appeared to have taken place at these points, probably as the result of vibration, the bar not being firmly held by its end bearing springs. All its other faces were surprisingly clean and bright, after such a long period of enclosure. The pound showed a few spots of "bloom," and a trace of surface filming, which were found subsequently to yield readily to the application of a little alcohol upon a clean wash leather. After inspection, the copies were removed to the Standards Department for the necessary comparisons to be carried out.

These tests having been completed, arrangements were made for formally re-immuring them on August 3. Mr. Percy Ashley, Assistant Secretary to the Board of Trade, gave a short account of the history of the Imperial Standards and their copies, after which Mr. J. E. Sears, Deputy-Warden of the Standards, produced the immured copies, and announced provisionally the results of their comparisons against the Primary Standards. They were then restored to their boxes, the greatest precautions being taken against any possibility of deterioration or injury.

The yard bar was placed in its mahogany box, resting upon its roller-lever frame, but was now insulated from the rollers themselves, and also from the end bearing-springs, by means of strips of mica, and it was more carefully padded to guard against vibration. The pound, after being wrapped in soft paper, was inserted in a silver-gilt thimble fitting into a bronze casket, which was enclosed in a cubical mahogany box. The screws securing the lids of the two boxes containing the respective standards were sealed by the Deputy-Warden. The outer enclosing oak case had been prepared by giving it several coats of red lead paint inside, and providing it with a new lead lining, within which the standards were now hermetically enclosed by soldering up. Nothing now remained but to secure the lid of the outer case, and restore the standards to the recess in the wall from which they had been taken a few weeks previously. The case was supported clear of the masonry by resting it upon slips of wood. An account of the proceedings, signed by the principal persons present, was placed with the box, together with a certificate, dated March 7, 1872, and bearing, among others, the signatures of both Airy and Miller. This certificate, which had been found when the recess was opened, testified to the fact that the standards were originally placed in their present position upon that date, after the wall in which they had previously been enclosed was demolished.

The results of the direct comparisons of the immured copies with the Imperial Standards, as announced by Mr. Sears, were as follows :—

Yard P.C. No. 4 = Primary Standard — 0·000101 in.

Pound P.C. No. 4 = Primary Standard + 0·00286 grain.

These figures are, however, provisional, since the results of the other comparisons, involving all the standards, will have to be taken into account in the final adjusted values.

It is scarcely possible to base any conclusions upon the hasty comparisons carried out in 1892, but the original verifications of these copies were, of course, carried out with the greatest care. The relations then arrived at were :—

Yard P.C. No. 4 = Primary Standard + 0·000007 in.

Pound P.C. No. 4 = Primary Standard — 0·00314 grain.

The apparent variation in the length of the yard may be disregarded. When one remembers that this amount of only one ten-thousandth of an inch represents the apparent variation in the relative lengths of two yard bars over a period of seventy years, and scarcely exceeds the experimental accuracy attainable at the time of their original verification, it is clear that the permanence of these standards may be regarded as fairly established. Baily's choice of the particular alloy to be employed in making the yards bars has been justified by results.

The apparent change in weight of the pound, amounting as it does to nearly one part in a million, requires a little more serious consideration. Whether a part of the difference may be due to a slight loss in weight of the Primary Standard is, for the present, undecided. Such a loss was reported by Mr. Chaney in 1892, as having occurred prior to 1878, owing to the not infrequent use of the primary in a series of important comparisons. Subsequent results did not fully support this conclusion, but further information will be available when the full series of comparisons which is still proceeding is completed. It is, however, probable that the greater part of the difference results from the character of the immured pound itself. It is by no means such a clean, smooth and polished piece of metal as would pass scrutiny to-day as being suitable to constitute a reliable standard weight. Its surface is, in a number of places, somewhat rough and pitted, giving a suggestion of the possibility of porosity. It has been drilled and plugged, and appears to have received some amount of ungentle treatment during manufacture.

Such being the case, an increase in weight arising from an accretion of foreign matter need not occasion surprise. The amount of the observed difference is much too great to be attributed to experimental error—most accurate balances of to-day would detect it at once—and the recognised permanence of platinum precludes any assumption that change has taken place in the material of the weight itself. For the moment, the matter must be left at this; but it adds to one's regret that it was not thought desirable to include the immured copies regularly when comparing the other standards, so that the progress of any apparent change could have been followed throughout.

ARBITRATION CLAUSES IN COMMERCIAL CONTRACTS.

THE Court of Appeal gave a judgment of great importance last month on the subject of arbitration clauses in commercial contracts. Messrs. Czarnikow and Co., Limited, had sold to Messrs. Roth, Schmidt and Co. about 20,000 cases of sugar by a contract which was made expressly subject to the rules of the Refined Sugar Association. The effect of No. 17 of these rules was that all disputes arising out of the contract were to be referred to the Council of the Refined Sugar Association as arbitrators. Rule 19 provided that the obtaining of an award under such arbitration should be a condition precedent to the right of either contracting party to sue the other in respect of any claim arising out of the contract, and that neither party should be entitled to require, nor should they apply to the court to require, the arbitrators to state in the form of a special case for the opinion of the court any question of law arising in the course of the reference, but such question of law should be determined by arbitration in accordance with the rules. A dispute arose between the parties as to whether the buyers were entitled to refuse to accept delivery of 7,574 cases of sugar. It went to arbitration before the Council of the Refined Sugar Association, and the buyers asked the arbitrators to state a case for the opinion of the court in terms of the Arbitration Act, 1889, on certain points of law, or if they refused to state a case, to defer consideration of the matter in order that the buyers might have an opportunity of applying to the court for an order asking the arbitrators to state a case. The arbitrators refused to comply with either of these requests, and issued their award.

The buyers applied to the court for an order that the award should be set aside on certain grounds, one of which was that the arbitrators ought either to have stated a case or to have given the buyers an opportunity of applying to the court for an order on them to state a case. They maintained that Rule 19, in so far as it excluded the right of the parties to get a stated case for the opinion of the court was void as being contrary to public policy. On the general question of the inadvisability of such a rule, Lord Justice Bankes said :—

"The ground of objection to the rule is that as an agreement it ousts the jurisdiction of the courts of law and is consequently against public policy and void. The importance of maintaining in its integrity the rule of law in reference to public policy is, in my opinion, a matter of considerable importance at the present time. Powerful trade organisations are encouraging, if not compelling, their members and persons who enter into contracts with their members to agree, as far as they lawfully can do so, to abstain from submitting their disputes to the decision of a court of law. The present case is a case in point. There have been others before the courts. Among commercial men what are commonly called commercial arbitrations are undoubtedly and deservedly popular. That they will continue their present popularity I entertain no doubt, so long as the law retains sufficient hold over them to prevent and redress any injustice on the part of the arbitrator and to secure that the law that is administered by an arbitrator is in substance the law of the land, and not some home-made law of the particular arbitrator or the particular association. To release real and effective control over commercial arbitration is to allow the arbitrator or the arbitration tribunal to be a law unto himself or itself, to give him or them a free hand to decide according to law, or not according to law, as he or they think fit; in other words, to be outside the law. At present no individual or association is, as far as I am aware, outside the law except a trades union. To put such associations as the Refined Sugar Association in a similar position would, in my opinion, be against public policy. Unlimited power does not conduce to reasonableness of view or conduct."

Lord Justice Atkin said that if the court's right, under the Arbitration Act, to intervene to compel arbitrators to submit a point of law for their determination were ousted, lay-arbitrators would be at liberty to adopt any principles of law they pleased. His Lordship continued :—

"In the case of powerful associations such as the present, able to impose their own arbitration clauses upon their members, and by their uniform contract conditions upon all non-members contracting with members, the result might be that in time codes of law would arise administered in various trades differing substantially from the English mercantile law. The policy of the law has given to the High Court large powers over inferior courts for the very purpose of maintaining a uniform standard of justice and one uniform system of law. Analogous powers have been possessed by the court over arbitrators and have been extended by the provisions of Section 19 of the Arbitration Act, 1889.

The court, although convinced of the inadvisability of such a clause as Rule 19, had to consider whether there was anything in the judgment of the House of Lords in the case of the Atlantic Shipping and Trading Company, Limited, *v.* Louis Dreyfus and Co. (referred to on page 461 of our issue of April 14 last), to prevent the court from deciding that the rule was void. In that case there was a clause in a charter party to the effect that all disputes arising out of it should be referred to arbitration, and that unless a claim were made in writing and the claimant's arbitrator appointed within three months of the final discharge of the

cargo, the claim should be deemed to be waived and absolutely barred. The House of Lords held that that clause was not contrary to public policy, and was valid. The distinction between the two clauses seems to be that the one merely put a time limit on the claimants' right to enforce their claim, while the other attempted to exclude the jurisdiction of the court altogether. The Court of Appeal accordingly considered that there was nothing in the House of Lords' judgment to prevent them from coming to the conclusion that the rule was contrary to public policy. The award was accordingly set aside.

There is a wide difference between the English law of arbitration as thus laid down by the Court of appeal and that of Scotland. In Scotland there is no statutory enactment enabling or compelling arbitrators to state a case for the opinion of the court, and arbitration clauses which exclude the court's jurisdiction are quite legal and valid.

RAILWAY BRIDGE LOADINGS.

By the adoption of standard typical loadings for railway bridges, the work of computing stresses can be very much simplified by the use of tables or diagrams drawn up once for all. With the aid of these it is possible to determine very easily and quickly both the maximum bending moment and the maximum shear produced at any section of the bridge during the passage over it of the typical train load. Some 30 years ago the late Theodore Cooper specified a system of such typical train loads which have been widely adopted in American practice. One of his typical trains consisted of two consolidation locomotives with 40,000 lb. on each driving axle, followed by a uniform train load of 4,000 lb. per lineal foot. This typical load was known as E. 40. Other standard loads were denoted by E. 30, E. 60, and so on, the number 30 implying that the driving axle loads were 30,000 lb., and the uniform train load 3,000 lb. per foot, whilst in the case of E. 60 these figures were doubled. It was hoped in this way that it would be practicable to provide for the secular increase of train loads by simply raising the constant to, say, E. 60 or E. 70, but according to a paper on "Locomotive Loadings for Railway Bridges," contributed to the Proceedings of the American Society of Civil Engineers by Mr. D. B. Steinman, this method has now broken down owing to the construction of extremely heavy locomotives in which the distribution of the weights departs widely from the consolidation type. Moreover, whilst axle concentrations have doubled within the past thirty years, the weight of trains per lineal foot has only increased 50 per cent.

The situation which has thus arisen, has been met for the most part by varying the Cooper rating with the span. Thus on the New York Central lines, Cooper's E. 70 rating is used for spans up to 200 ft., and his E. 75 rating for longer spans. The rating is also adjusted in some cases according to the character of the bridge member, being E. 70 for the floor system and E. 60 for the truss members. Mr. Steinman suggests that, in place of making more or less arbitrary adjustments of this type, the time has come to abandon the Cooper system entirely, and to introduce new systems of standard loadings designed to meet the actual conditions. To this end he has studied the maximum moments and shears produced by one or a pair of the seven heaviest engines now in service followed by a uniform load of 6,000 lb. per lineal foot. From the figures thus obtained he has deduced the equivalent uniform loads which would give rise to the same maximum moments and shears. These equivalent uniform loads vary, of course, not merely with the span, but also with the position of the load on the span, and his paper includes accordingly tables and diagrams from which the required figure can be obtained at sight. At the same time he has devised a formula by which these equivalent loads can be very rapidly computed, with an accuracy more than sufficient for practical requirements.

The basic loading he proposes is denoted by M. 10. An equivalent uniform load, which will produce the same bending moment at mid-span is easily found, but what is wanted is an equivalent load giving the correct bending moment at all points. Denoting this by q, Mr. Steinman finds that for the M_{10} loading:

$$q = 833 + 10{,}000\frac{\sqrt{l_2}}{l_1+l_2}$$

where l_2 denotes the longer of the two sections into which the span is divided by the point at which the moment is sought, and l_1 the shorter section. Other typical loads are found by multiplying the constants in the above formula by 4, 5, 6, &c., the highest multiple contemplated being 9, which is designated as the M. 90 rating.

The rating M. 60 gives stresses for all spans very close to the maximum stress producible by the heaviest existing locomotive loading. Having obtained q, the maximum bending moment at any point is given by $M = \frac{1}{8} q\, l_1\, l_2$. Another system of uniform loads gives the maximum shear produced at any point of a bridge. For the M. 60 rating this system of uniform loads is as follows:—

Equivalent Uniform Loads for Shears and Reactions. ($l_1 = o$).

l_2 ft.	q lb. per ft. run.	l_2 ft.	q lb. per ft. run.	l_2 ft.	q lb. per ft. run.	l_2 ft.	q lb. per ft. run.
1,000	6,897	300	8,460	160	9,740	60	12,740
900	7,000	280	8,580	140	10,070	50	13,480
800	7,120	260	8,720	120	10,480	40	14,490
700	7,260	240	8,875	100	11,000	30	15,980
600	7,450	220	9,045	90	11,325	20	18,420
500	7,680	200	9,240	80	11,710	10	23,970
400	8,000	180	9,475	70	12,170		

The maximum end reaction is found by taking q from this table and multiplying it by the half the span. At any intermediate section the maximum shear is given by the relation $V = \frac{1}{2} q l^2 \left(\frac{l_2}{l}\right)$, where l_2 denotes the longer segment of the span and l the total span. Similarly the maximum floor reaction or stress in hanger is given by the expression

$$R = \tfrac{1}{2} q (L_1 + L_2),$$

where L_1 and L_2 are the adjoining panel lengths. For other ratings the values of q are reduced in exact proportion to the rating.

NOTES.

Danger from Miners' Portable Lamps.

It has often been assumed that an electric lamp will not cause an explosion when the bulb is broken in an atmosphere of explosive gas owing to the filament being so thin that it would be consumed instantaneously when the vacuum is destroyed even if it survived the shock causing the breakage of the glass. That this view is incorrect, at any rate as regards the miniature bulbs used in miners' lamps, seems to have been effectively demonstrated by experiments carried out with such bulbs in America, and reported in Serial 2,371 of the United States Bureau of Mines. The investigations were undertaken on account of doubts expressed as to the necessity of the safety devices which were compulsory in connection with miners' portable lamps in the United States. These devices were required to open the circuit automatically in case the bulb became broken and several types were approved as satisfactory. The lamp bulbs used in the experiments were of the 2-volt pattern, some taking 0·85 ampere and others 0·6 ampere. In some tests the glass bulb was carefully broken away beforehand, and the naked filament switched on in an explosive mixture, and in others the lamp was smashed when lit and surrounded by explosive gas. In 10 consecutive tests under the former conditions a violent explosion occurred, the filament remaining unbroken. In 10 tests in which the burning lamp was smashed, 8 explosions resulted, and in 6 of these the filament remained lit for several seconds after the explosion. Altogether 55 tests were made with various explosive mixtures of air with natural gas and petrol vapour, and 51 ignitions resulted. The experiments are entirely convincing, and confirm the authorities in their view that automatic current-interrupting devices are necessary on the grounds of safety. It appears that there is a sufficient time-lag in the ignition of explosive mixtures to permit such devices to be effective, although the time-lag itself is too short to allow the filaments to burn themselves out before the explosion occurs. It should be remembered that the results obtained refer to low-voltage miniature lamps only, with their comparatively thick and hardy filaments, and it is likely that the effect would be different in the case of ordinary electric light bulbs.

The South-Eastern and Chatham Railway Electrification.

The Electricity Commissioners have issued a statement with regard to the supply of power for the proposed South-Eastern and Chatham Railway electrification. The railway company expect to complete the first stage of their electrification by June 30, 1925, and under the Trade Facilities Act have an arrangement with the Treasury for a loan of 6,500,000*l*. The company proposed to erect a power station at Angerstein's Wharf, Charlton, capable of generating 60,000 kw., and claimed that this station could be subsequently enlarged to generate 150,000 kw., so that it would be in a position to supply the London, Brighton and South Coast Railway, in addition to meeting the requirements of its own further electrification programme. The Commissioners are not of opinion that the design of the power station would lend itself to expansion to the size contemplated, while they are of the opinion that it is possible that the West Kent Electric Company, Limited, and the County of London Electric Supply Company would both be in a position to supply current to the railway, if the necessary arrangements could be made. The West Kent Company is prepared to go ahead with its Belvedere station if they secure the contract with the railway company for supply for a minimum of sixty years. The County of London Company is proceeding with its Barking Station and is prepared to give a supply on a contract for twenty-five years. This supply would involve, among other things, a tunnel under the Thames for cables, but no difficulties are anticipated in connection with these points. The Commissioners, therefore, before giving a final decision, consider that the railway should enter into negotiations with the supply companies to discuss actual terms of a contract, including a guarantee to indemnify the railway company in the event of the supply not being forthcoming at the required time. The Commissioners consider it possible that such a contract could be made.

THE BRITISH ASSOCIATION.

The city of Hull, in which the British Association will meet on Wednesday, September 6, has once before welcomed the Association, viz., on Wednesday, September 7, 1853. At recent meetings there has always been a fair number of old members who remembered their previous visit to the same town, and sometimes to the same buildings. The 69 years interval between the two visits to Hull, the longest interval recorded in the annals of the Association, almost precludes that possibility. Meanwhile, much of old Hull has vanished. Hull justifies the epithet, "the bright and scientific town," which Gent applied to it in his history of 1735, in a more modern sense; its docks have extended with its shipping trade, which increased sixfold in the half century following the 1853 meeting, and they have made Hull the third port of the Kingdom in point of tonnage arriving and departing, while the population has trebled—being in 1921 287,033.

Though an ancient important town and borough, which has sent two members to Parliament since 1298, Hull has not played a conspicuous part in the history of the kingdom, and is probably contented with not having been more prominent. Wyke-upon-Hull is mentioned in 1160; the settlement was situated, partly below sea level, as now, on the right western bank of the river Hull, near its junction with the Humber, there, 22 miles from the North Sea, two miles wide. Edward I, staying at Cottingham Castle near by, granted the first charter to what was then styled "Kingston-sur-Hull" (later Kingston-upon-Hull) in 1299; a new charter was given by James II in 1688. Edward I is considered the founder of the town. He gave it a Royal mint and the privilege of exporting wool and leather. But Hull had rival ports in Hedon, York and Ravenspurne. Ravenspurne has long since been swallowed up by the sea, with other towns on the Holderness, and York was too high up the Ouse to become a shipping centre. So Hull developed. A Trinity

House Guild was founded in 1369. The Trinity House Marine School, with which a museum is now connected, dates from 1716, and the present Trinity House from 1753. Holy Trinity Church, famous for its nave, 272 ft. long, and its beautiful western front, was completed in the fifteenth century; but it is much older in parts, and contains the tomb of William de la Pole, a merchant shipowner and mayor of the town, the first of the unfortunate line of the Suffolks. Michael de la Pole, Earl of Suffolk, established a charterhouse for the old and feeble in 1389. In the same year the two members for Hull were exempted from attending Parliament to curtail expenditure, the money being granted for building. In the War of the Roses Hull was strongly Lancaster and Red Rose, whilst Yorkshire on the whole supported York and the White Rose. During the Civil War Charles I was refused admission into the town.

The Queen's docks, excavated in 1774 on the grounds of the former fortifications, were among the first of the kingdom. The Humber Docks (1859), Princes Docks, Railway Docks and Victoria Docks followed, the last mentioned in 1860; by 1869 the Albert Docks were finished. The William Wright Docks (1880), St. Andrew's Docks (1883), Alexandra Docks (1885), and the new joint docks (since 1908) brought the whole dock area up to 187 acres. The King George Docks, finally added in 1914, increased that total by 53 acres. These modern docks accommodate the largest steamers, and also rank with the best equipped of their kinds as regards warehouses, oil and coal storage, and railway connections. The Victoria or Corporation Pier, facing the Humber, is the only railway station in the kingdom which has no train service; it serves as terminus for the Great Central Railway, which sends its ferries over from New Holland, on the Lincolnshire side of the Humber. Since 1888 the administration of the ports of Hull and of Goole, 24 miles up the river, on the junction of the Don and Ouse, has been united under one Humber Conservancy Board.

Goole, merely a hamlet a hundred years ago, owes its growth to the construction in 1826, by the Aire and Calder Navigation Company, of the Knottingsley Canal, which has made Goole a centre for inland navigation, whilst Hull has more and more developed into a seaport, and a centre of the fishing, shipping and shipbuilding industries. The docks were, till 1893, owned by the Hull Dock Company, and were then taken over by the North-Eastern and Hull and Barnsley Railway Companies. The glass and sugar industries would not prosper in Hull. Cotton, flax and worsted once had their time, as did also whaling; but the last whaler started from Hull in 1865. On the other hand deep-sea fishing and curing are thriving; the cement works of Messrs. Earle flourish; the timber yards cover many acres; the Hull fruit and the frozen Russian egg trades are, or were, famous; and during the war the seed-crushing trade has been taken up with much success, oilcakes, cattle food and flour being now important products. The situation of Hull, at the foot of the Yorkshire Wolds, in a thinly-populated area, which has no other big towns, has facilitated this development.

Intellectually, Hull may claim equal advancement. William Wilberforce, the abolitionist, who since 1787 exposed the evils and horrors of the slave trade in Parliament as member for Hull, was born in the Lister House, an old Elizabethan building of Hull. His ancestors had, since Henry II's time, held the manor of Wilberfoss, in the East Riding. The Wilberforce column, erected in the centre of the city, between the Queen's and Princes Docks, is the most noteworthy monument of the city. Bishop Samuel Wilberforce, upon whom Huxley's wrath rightly descended at the Oxford British Association meeting of 1860, was his third son. The Royal Institution, the home of the Literary and Philosophical Society of Hull—which will harbour the Anthropological Section, and in its museum the Geological Section during the meeting—was opened by Prince Albert in 1854. Since that time the late J. R. Mortimer and others have done a great deal in excavating the earthworks, burial mounds and other remains of the Britons, Romans, Saxons and Danes who lived on the once thickly populated chalk wolds of Yorkshire, and the Hull museums are rich with those finds, as also with geological exhibits from the glacial sands and clays of Holderness. "The Relations of Early Man to the Phases of the Ice Age" is one of the subjects to be discussed at the coming meeting.

The Municipal Training College for Teachers, opened in the year before the war, will not accommodate any of the meetings; but the Municipal Art School will house several Sections. The various Section rooms are rather dispersed, and several of them are quite half a mile from the Reception room, in the Guildhall, which, with the luncheon room opposite, lies at the one end of the official buildings placed at the disposal of the Association.

When the Association met in 1853, William Hopkins, of Cambridge, geologist and mathematician, was the president, and another geologist and distinguished member of the Association, John Phillips—an opponent of Darwin's, by the way—was the first of the two evening lecturers. Robert Hunt, the other lecturer, discoursed upon "The Present State of Photography," a discourse which would have a curious interest now. In 1853 W. Fairbairn occupied the chair in Section G.

This year's president-elect of the Association, Sir Charles S. Sherrington, Pres.R.S., is a physiologist, and his address, to be delivered in the City Hall, on Wednesday, September 6, at 8.30, will be devoted to Some Aspects of Animal Mechanism. In 1853 physiology was a subsection of D. Zoology.

The total number of members attending the first Hull meeting in 1853 was 876. That number has already been exceeded by the number of members registered for the meeting this year. A large meeting is hardly anticipated; but the local interest is strong, and the presence of some eighty science students, picked from universities and colleges, will be an innovation; they will be accommodated in a hostel. Most of the sectional programmes are certainly attractive, and if not quite so long as they have sometimes been, that is not, on the whole, a disadvantage. It will be a full week's meeting, lasting from Wednesday, September 6, to Wednesday, September 13. The Saturday will be left free for excursions, both general and special, and only a few sections (comprising G, Engineering) will meet on the second Wednesday, but the sectional proceedings will extend into the afternoons in most cases.

We published the programme of Section G., Engineering, so far as then settled, on page 177 of our issue of August 11. Some additions have to be made. In the discussion, on Wednesday, September 7, on the "Strength of Railway Bridges," Mr. A. G. Cookson and Mr. J. S. Nicholas (not only Mr. Cookson) will refer to the proposals of the Ministry of Transport. To the discussion to be held on Monday, September 11, on "Economic Steam Production," Dr. C. H. Lander will contribute a paper on "Home-produced Oil Fuel"; Engineer-Commander Fraser Shaw, R.N., will deal with commercial economy and fuel economy, and Engineer-Commander R. Beeman, R.N., with the same factors from the naval point of view. The joint discussion with Section L, Education, arranged for Tuesday, on "The Effects of Reformed Teaching of Mathematics," will be held in the rooms of L; papers are to be read by Professor T. P. Nunn on the "Principles of Formal Geometry," and by Mr. R. C. Fawdry on the "Practical Result of the Reform." The title of the paper to be read by Dr. E. F. Turner in Section G., on Wednesday, September 13, will be "Electrical Ignition Apparatus for Internal Combustion Engines." Professor G. W. O. Howe, of Elmwood, Surrey, is Recorder of the Section, as we stated. All the sectional proceedings begin at 10 a.m. and are preceded by meetings of the sectional committees.

In Section A, Mathematical and Physical Science, Professor G. H. Hardy, F.R.S., of Cambridge, will preside; the Recorder is Professor A. O. Rankine, Imperial College of Science and Technology, S.W. 7. On the first Wednesday the Section will subdivide. In the main section Professor P. Langevin, of Paris, will open a discussion on the "Origin of Magnetism," in which Professor P. Weiss, of Geneva, Sir J. A. Ewing, Dr. A. E. Oxley and Mr. L. F. Bates will take part, and Mr. M. A. Giblett will afterwards describe the methods employed in meteorological observations, in connection with a Meteorological Exhibition to be held in the Guildhall. The subsection on Cosmical Physics will discuss "Weather Cycles in Relation to Agriculture and Industrial Fluctuations," in a joint meeting with Sections F and M. On Wednesday afternoon, at 5 p.m., Sir William Bragg will lecture on the "Significance of Crystal Analysis." On Thursday, September 7th, Professor Hardy will deliver his presidential address on "The Theory of Numbers;" papers on radioactivity will then be taken, by the Duc de Broglie on "X-Rays and β-Rays," and by Professor R. Whiddington on "X-Ray Electrons"; Professor H. H. Turner will present the Report of the Seismological Committee. At 2 p.m. Professor J. Proudman will lecture on "Tides, with Special Reference to the North Sea."

Monday, September 11th, will be devoted to a joint discussion of Section A with Section I., Physiology, on "Physical Instruments for Biological Purposes." This discussion will be opened by Professor A. V. Hill, F.R.S., and Major W. S. Tucker, Professor H. E. Roaf, Mr. F. E. Smith, F.R.S., Mr. Somerville Hastings, Mr. R. S. Whipple and Lieutenant-Colonel C. B. Weald will take part. The instruments to be exhibited comprise Apparatus for Testing Hearing and on Standard Sources of Sound (exhibitors, Major Tucker and Mr. F. E. Smith), a Model of Resonating Mechanism of the Cochlea (Dr. G. Wilkinson), and various apparatus, including the Salomonson String Galvanometer and the MacGregor-Morris Anemometer, shown by the Cambridge and Paul Instrument Company. For Tuesday various papers are announced, by Professor A. W. Porter, on the "Law of Distribution of Particles in a Colloid Suspension"; by Mr. F. Jackson (of Greenwich) on "Double Stars"; by Professor R. Whiddington, on the "Ultramicrometer for Minute Physical Measurements"; by Mr. J. E. P. Wagstaff, on the "Determination of Dielectric Constants and Susceptibilities by Valve Methods"; and by Mr. J. Ewles, on "Cathode Luminescence in Relation to States of Molecular Aggregation." A joint discussion with Section E, Geography, to be held in E, on "Monsoons" (Dr. G. C. Simpson, Director of the Meteorological Office; Mr. W. G. Kendrew, Mr. G. J. Chisholm, Dr. H. Jeffreys), will bring the proceedings to a conclusion.

In the Chemistry Section B, which will meet in Waltham-street Hall (President Principal G. C. Irvine, F.R.S., of St. Andrews; Recorder, Professor Cecil H. Desch, of Sheffield), organic and physical chemistry will predominate. Professor Irvine will deliver his address on "Research Problems in the Sugar Group," on Thursday; Dr. Helen Gilchrist (on the "Preparation and Constitution of Synthetic Fats"), Mr. John Preedy ("Nitrogenous Sugar Derivatives") and Dr. H. E. L. Hirst (on the "Composition of Esparto Cellulose") and Sir W. H. Bragg (on the "Crystalline Structure of Organic Compounds") will follow. For the afternoon at 2 p.m. a joint discussion with Section K., Botany, is contemplated on "Photosynthesis," to which Dr. F. F. Blackman (Biochemical Problems), Professor E. C. C. Baly, Mr. G. E. Briggs, Professor I. M. Heilbronn and Dr. C. Hollins and Dr. F. C. Eve will contribute papers; there has been considerable progress in this domain of late. On Friday the problems of "Valency and Polarity" will be discussed by Professor R. Robinson (with respect to organic compounds), Dr. J. Kenner ("Significance of Induced Polarity"), Dr. N. V. Sidgwick, Professor A. Smithells and others. Later on Mr. E. D. Williamson will read a paper on the "Determination of Compressibilities and Applications to High-Pressure Chemistry," and Dr. A. F. Holeman will speak on the "Rule of Conservation of Substitution-Type in the Benzene Nucleus." On Monday the important "Hydrogenation of Fats" will be discussed by Dr. E. F. Armstrong, Mr. E. R. Bolton ("Technical Aspects of Hydrogenation"), Dr. J. P. Hilditch and others, and Professor J. W. McBain will then explain methods in use for the Study of Soap Solutions. On Tuesday the Nitrogen Industry is to be discussed in connection with papers by Mr. J. H. West (on the

"Manufacture of Hydrogen and Nitrogen"), by Mr. C. J. Goodwin (on the "Häusser Process"), Dr. E. B. Maxted and others. Reports will also be presented by the Fuel Economy Committee, and by Dr. J. S. Owens on "Atmospheric Dust."

In Section C, Geology, which will meet in the Royal Institution, and also in the Queen's Hall (President, Professor P. F. Kendall; Recorder, Professor A. R. Dwerryhouse, of Reading), the interesting geology of the district will receive due attention. Professor Kendall will himself open, on Wednesday, a discussion on the "Geological History of the North Sea Basin," to which Mr. J. O. Borley will contribute a paper. Mr. Thomas Sheppard will follow with a lecture on the "Geology of the Hull District," and Mr. C. Thompson with a paper on the "Erosion of the Holderness Coast," which he finds proceeds at a rate slightly slower than was feared. The subject of the Presidential address, to be delivered on Friday, will be the "Physiography of the Coal Swamps." Wegener's "Hypothesis of Continental Drift" will come up for discussion, by Dr. J. W. Evans, Professor H. H. Turner (from the astronomical evidence), and Mr. W. B. Wright. On the same day Dr. Herbert Hawkins will raise the question of the "Relation of the River Thames to the London Basin." The already-mentioned discussion of the "Relation of Early Man to the Phases of the Ice Age in Britain" is set down for Monday afternoon, in the rooms of Section H. Section E, Geography, is also to take part, and Messrs. P. F. Kendall, H. J. E. Peake, S. Hazzledine Warren, H. J. Fleure, L. S. Palmer, P. H. G. Boswell and C. E. P. Brooks are to speak. Professor A. P. Coleman, from Canada, will lecture on "Pleistocene and Recent Ice Conditions in North-Eastern Labrador," on Friday morning.

Section D, Zoology (President, Dr. E. J. Allen, F.R.S.), has an equally long and instructive programme. Dr. Johannes Schmidt, of Copenhagen, will discourse on the "Dana Expedition in the North Atlantic," and a discussion on the "Fauna of the Sea Bottom" will be opened by Dr. C. G. J. Petersen, and be continued by Messrs. F. M. Davis, J. O. Borley, R. D. Laurie, E. E. Watkins, and Miss E. Horsman—all this on the Thursday.

On the Friday morning Dr. E. J. Allen will deliver his presidential address on the "Progression of Life in the Sea," and after that, both in the morning and afternoon, "Sea Fisheries, and especially Herring Fisheries," will be discussed by Mr. G. Hall, Professors J. Hjort and Otto Pettersson, Messrs. David Jones, B. Storrow, W. Wallace and others, the opener, Mr. J. A. Robertson, and Dr. E. S. Russell, Mr. H. G. Maurice, and J. Stanley Gardiner dealing particularly with "Fluctuations in Sea Fisheries." Monday's discussion on the "Present Position of Darwinism," in conjunction with Section K, Botany, is not likely to be dull. Dr. J. C. Willis, Mr. G. Udney Yule ("Mathematical Conception of Evolution, based upon the Theory of Age, Size and Space"), Messrs. G. Tate Regan, J. T. Cunningham, and H. Wager will hardly be in agreement, and the staunch Darwinists—the term will not be misunderstood, we hope; it is not meant to be critical—will, we trust, not keep away.

Some of the debates in Sections E., Geography (President, Dr. Marion I. Newbigin), and F., Economic Science and Statistics (President, Professor F. J. Edgeworth), may assume a political character. Dr. Newbigin will address E. on "Human Geography; First Principles and Some Applications"; Mrs. H. Ormsby will deal with the "Danube as a Waterway"; Professor J. F. Unstead with the "Belt of Political Change in Europe"; Mr. R. R. Walls with "Geographical Problems of Nyassaland." Other papers, less likely to verge on politics, are those on the following subjects: Miss E. C. Semple on "Influence of Geographic Conditions upon Ancient Mediterranean Agriculture," Sir Philip Brocklehurst "Through Wadai," Mr. H. M. Spink on "Some Geographical Aspects of Recent Water Power Developments," Mr. A. V. Williamson on "Irrigation in the Indo-Gangetic Alluvium," and Mr. E. A. Frazer and Mr. F. Debenham on "Topographical Work and Survey in Spitsbergen and in the Polar Regions." Colonel E. M. Jack is to open a discussion on the "Use of Mercator's Projection for Air Maps," which is to be continued by Professor H. H. Turner. Various papers will be of particular local interest: Mr. Ll. Rodwell Jones on the "Port of Hull," Mr. C. Midgley on "Holderness and Water Supply," and Mr. C. B. Fawcett on the "Distribution of Population in Yorkshire." Mr. T. Sheppard will exhibit his unique collection of Maps of Hull and the Humber Estuary. Mr. D. C. T. McKie will take a historical line in his paper on the "Trend of the World's Commerce."

In Section F Professor Edgworth will deliver an address on "Equal Pay to Men and Women for Equal Work." Progress in the solution of some of the problems discussed in the following papers will be very welcome: "Increasing the Food Supply of the Nation" (with Section M., Sir Henry Rew, Sir John Russell, Sir T. Middleton, Professors E. Cannan and W. Somerville); "Modern Municipal Markets" (Professor J. G. Smith); "Controlling Industrial Fluctuations" (Mr. C. F. Bickerdike); "The Poor Law in Relation to the Able-Bodied" (Miss A. Ashley); "The Future of Unemployment Insurance" (Mr. J. L. Cohen); and "Human Motive Power in Industry" (Miss H. Reynard). Professor A. L. Bowley will also compare "Wholesale and Retail Prices since the War."

Section G we have already dealt with above. The transactions of Section H., Anthropology, are always most interesting, and so will be the presidential address by Mr. H. J. E. Peake on the "Study of Man," as well as the papers to follow. But Section I., Physiology, may appeal more directly to the engineer with its presidential address by Professor E. P. Cathcart on the "Efficiency of Man and the Factors which Influence It," Dr. F. C. Eve's paper on "Life and Energy," the discussion on "Vitamines" (with Sections I. and M.), and Dr. F. W. Edridge-Green's papers on "Colour Vision and Colour Blindness" and on the "Necessity for a Standard of White." Dr. T. R. Rodger's paper on "Loud Noises and the Cochlea" will bring up the question of the deafness of boilermakers, but it will, like some other papers, hardly have much technical interest so far, we are afraid. That may apply also to some of the transactions of Section J., Psychology (president, Dr. C. S. Myers), though the papers on "Industrial Psychology and the Efficiency Engineer" (Dr. Myers), "Problems of Industrial Psychology" (Dr. G. H. Miles), "Practical Applications of Vocational Psychology" (Mr. J. Seebohm Rowntree, Junior), "Value of Output Curves as Measure of Fatigue" (Mr. Eric Farmer), and "Mental Deficiency" (Drs. F. C. Shrubsall and G. A. Auden) will have a direct practical bearing.

Section K., Botany, will have a long programme. We have mentioned the joint discussion on "Photosynthesis"; the president, Professor H. H. Dixon, F.R.S., will address the Section on the "Transport of Organic Substances in Plants," and there will be several papers on "Forestry," by Lord Lovat, Dr. A. W. Borthwick and Professor A. Henry ("Cultivation of Poplars").

Section L., Education, will be addressed by Sir Richard Gregory on "Educational and School Science." There will be discussions (with Section J.) on "Psychoanalysis and the School," on the "Reformed Teaching of Mathematics" (with Section A., already mentioned), on "English as Basis of National Education" (Mr. G. R. Pocock and Professor Edith Morley) and upon "Individual Work in Schools, with special reference to Experiments in Hull" (Miss F. Sayer and Miss C. T. Cumberbridge on the "Dalton Plan"), as well as papers on "International Students Organisation" (by Mr. Ives on "Macadam") and others. The question of Training in Citizenship has been a prominent subject in L at recent meetings. It will this year be raised by Lord Merton and by Sir Joseph Cook (High Commissioner for Australia).

Section M., Agriculture, finally will take a leading part in several of the discussions already referred to. The president, Lord Bledisloe, will address the Section on the "Proper Position of the Landowner in relation to Agricultural Industry"; Mr. E. A. Fisher will speak on "Evaporation of Water from the Soil"; and Sir Daniel Hall on "Land Reclamation on the East Coast."

Two evening discourses will be delivered, the first, on the Friday, by Dr. F. W. Aston on the "Atoms of Matter, their Size, Number and Construction," and the second by Professor D'Arcy W. Thompson on "Fishing, Old Ways and New." There are further planned four Citizen Lectures, and, an innovation, Lectures for Children, by Professor H. H. Turner (on the "Telescope and what it Tells Us"), by Professor J. Arthur Thomson (on "Creatures of the Sea") and by Mr. F. Debenham (on the "Antarctic").

Thus the British Association will prove itself alive to the importance of the pressing economic and industrial problems of the day. The concluding general meeting will be held in Queen's Hall at noon on Wednesday, September 13.

The Air Ministry will daily exhibit synoptic weather charts and forecasts in the Reception Room, which will be opened on Monday, September 4. The British Association offices in Burlington House, W. (Mr. O. J. R. Howarth, M.A., Secretary), will be closed on September 2. Dr. E. H. Griffiths, F.R.S. (General Treasurer) and Professor H. H. Turner, F.R.S., and J. L. Myres (General Secretaries) remain the general officers. The honorary local officers at Hull are: Mr. T. G. Milner (City Treasurer, and Mr. H. A. Learoyd (Town Clerk), and Mr. T. Sheppard, M.Sc., (Museums Curator) secretaries.

LITERATURE.

Rubber Manufacture; The Cultivation, Chemistry, Testing and Manufacture of Rubber, with Sections on Reclamation of Rubber and the Manufacture of Rubber Substitutes. By H. E. Simmons, Professor of Chemistry, University of Akron, Ohio, U.S.A. London: The Library Press. [Price 25*s.* net.]

The title of this work is sufficiently comprehensive, and being dated from Akron, the Mecca of the rubber industry, promises a thorough review of the most approved processes of production and manufacture of this important article of commerce. This hope, however, is scarcely realised, and is perhaps not realisable within the moderate limits the author has allowed himself. Of course, it is readily admitted, as one of the difficulties with which he has had to contend, that many details are close trade or proprietary secrets, the consequences of diligent research and long experience, to be retained by the firm whose energy and enterprise have brought experiment to a successful result. Instinctively, such knowledge is closely guarded, but it is a question if this policy of secrecy is not carried too far and may in the end act detrimentally to those who employ their own technologists. The combined directive effort of the whole army of technical experts, besides preventing much unnecessary overlapping, would grow more quickly and provide results of greater value than the sum of the isolated labours of individuals or small groups of experimenters. In the present method of competitive working such a course, however, is out of the question, and the author does not attempt to give details either of the construction of machinery or of the methods of its application. He is content to exhibit the principles that determine the one and the objects sought to be effected by the other. This course may have been dictated by the wish to present the technical details in a form that will be appreciated by the student, and at the same time attract the non-technical reader, who should be deeply interested in the progress and methods of a comparatively new industry. It is difficult to serve both classes, and apparently "the man in the street" has been catered for more successfully than the chemist or the engineer.

Interesting, but brief, descriptions are given of the early trade in caoutchouc, and of the method of collecting rubber in the Amazon basin when this region formed the main source of the world's supply. A century ago less than 30 tons of the commodity were exported, and by 1850 an export trade of 150 tons sufficed the world's commerce. During the present century, which has witnessed the phenomenal growth of the plantation rubber trade, the amount exported has remained practically stationary, while a space of ten years has seen the cultivated rubber trade advance from the modest contribution of 8,000 tons to the overwhelming figure of 358,000 tons. No attempt is made to explain the lack of energy which the South American

authorities have exhibited in face of this severe competition, or to account for the failure to retain a valuable trade in which they held a virtual monopoly. It was not the shortage of trees or of labour, and Para rubber has always maintained a higher price in the market than the plantation varieties. In the absence of any attempted explanation of a very curious problem in trade development, one has some hesitation in accepting the expressed opinion "that the plantations in the East are not going to be able to compete with the West in the future." We have unfortunately seen the supply greatly exceed the demand, and the day that the author foresaw "when there will be so much crude rubber on the market that it will not pay a return sufficient to justify the continuance of the industry," is upon us, with calamitous effect to our Colonial trade. But for the rubber lands to go back to primeval jungle, from which they have been won by labour and intelligence, would intimate a backward movement, more disastrous to colonial development than the negligence exhibited by the Brazilians in permitting the shift of the rubber activities from the Amazon to Malaya. It may be doubted if Mr. Simmons has correctly diagnosed the position. He regards the labour situation as of extreme importance, but since no extension of cultivated area can be contemplated for some time, no fresh sources of supply are needed. It is quite possible that the rubber plantation industry will come more and more under the control of the Chinese, whose operations are already so considerable, that their unwillingness to adopt the self-denying measures proposed by the European element has brought to naught the scheme of raising prices by restricting output.

The methods of collecting the latex as practised in the several rubber producing countries are sufficiently described. The most interesting of these, as it is the one about which we know the least, is that applied to the Mexican shrub, popularly known as Guayule. The usual method of bark tapping, or bleeding, cannot be applied to that plant, for the rubber exists in the cells of the plant itself. The plan usually adopted consists in grinding up the wood finely and adding naphtha to the mass. The resulting solution is partly distilled, and to hold the resins in solution, alkali is further added, the rubber separating out. The trade value of this form of collection is not stated, but it must be small in comparison with that due to the tapping processes, to which so many variations have been suggested in the hope of increasing not only the amount of latex per tree, but to obtain a more uniform product for the after operations of coagulating and curing. In respect of uniformity, it cannot be said that any method of treatment has been devised which gives complete satisfaction to the manufacturer. The reasons for this disappointment are outlined carefully. The planter is faced with physical, biological and chemical problems of complicated character that defy exact solution. Minute changes in cultivation, in climate, in the manner of tapping, in the time of resting the trees, give rise to variations in the character of the latex that cannot be foreseen and provided for. Further, with the view of hastening operations and saving labour costs in the preparation of the crude rubber, a number of coagulents and so-called "improvers" of unknown composition are employed, whose action cannot be completely traced but whose influence on the final result is not negligible. The acetic acid, usually the agent in coagulating, varies in purity, and the methods of mechanical treatment are not without effect. The outcry of the manufacturers demanding greater uniformity in the product is likely to be long continued. A very good account is given of the present position of the entire problem, and the suggestive experiments of Eaton and Grantham, so full of promise, are given prominence. The value of chemical research is vindicated by the excellent results obtained under rigorous supervision in the laboratory, but in the field, operations have often to be carried out in a rather haphazard way by native collectors, and these are apt to lead to confused and disturbing results. How far the trade has benefited from protracted inquiry is not clearly defined, and generally, though the growth of chemical theories are traced with sufficient fullness, technical processes, as those of vulcanisation, receive scanty consideration in the book under notice.

The value of experiment in indicating improved methods of manufacture fails to be fully appreciated owing to the want of reliable means of testing. The finished product is undergoing slow, but continuous change, owing to the presence of sulphur, and moreover, there is some evidence to show that the latex contains constituents, operating as catalysts, that are not precipitated by ordinary coagulation and whose action varies with time. The author's experience makes him mistrustful of the adequacy of testing methods. "After all has been done that experiment can effect," he reminds us, "that there is no satisfactory answer to the question, 'How will the rubber conduct itself during vulcanisation'?" Regretfully, it is admitted that "the only conclusive information is to be gained by trying it."

A chapter is devoted to the production of synthetic rubber, the unrealised dream of the experimental chemist. Fifteen or twenty years ago its achievement offered a tempting prize, tantalisingly dangled before the eyes of the ambitious experimenter. To-day, when the price of plantation rubber has fallen to an unremunerative figure, the pecuniary reward is too small to be attractive. The history of baffled endeavour, when the goal seemed so easy of attainment, is well told. The only link wanting in the chain of success was the discovery of a method capable of producing on a commercial basis what already existed as a chemical curiosity. Some day the process so easily expressed as a chemical reaction will be realised, but the owners of rubber securities will regard the achievement with indifference.

Other chapters of interest treat of the manufacture of fillers and rubber substitutes, inquiries somewhat remote and foreign to rubber production, properly so called. But some of these adulterants are introduced to such an extent in some articles that the use of the term rubber becomes a misnomer. It is really remarkable, says Mr. Simmons, to what extent "factis"—the product of heating certain oils with sulphur—"may be used in rubber without destroying the elastic properties. In fact, it may be added up to the proportion of 1 : 1." Narrowly connected with the subject of substitutes is the process of removing the sulphur and reclaiming the rubber, which can be subsequently used with virgin material. The process has been the object of many patents, all of which claim to be able to remove the whole of the sulphur from the rubber, but in spite of this claim, no sulphur-free shoddy is to be obtained on the market. The remaining sulphur indicates that there is a limit to the number of times the same rubber may be put through the reclaimer.

BOOKS RECEIVED.

Technische Träume. Von HANS GUNTHER. Zurich: Rascher and Cie. [Price 50 marks.]

Marine Engines. By A. RITCHIE LEASK. London: Simpkin, Marshall and Co., Limited. [Price 21*s.* net.]

The Uni-Flow Steam Engine. By Prof. Dr. Ing. L. C. J. STUMPF. Second edition. Syracuse, N.Y.: Stumpf Uni-Flow Engine Company, Inc.

A Key to Health and Long Life. (The Secret of Healthy Nutrition). By F. W. D. MITCHELL, I.S.O. Second edition, revised and enlarged. London: C. W. Daniel, Limited. [Price 6*s.* net.]

Our Homeland Prehistoric Antiquities and How to Study them. By W. G. CLARKE, F.G.S. London: The Homeland Association, Limited. [Price 4*s.* 6*d.* net.]

Waterworks for Urban and Rural Districts. With Notes on the Supply for Mansions and Isolated Buildings. By HENRY C. ADAMS, M.Inst.C.E., M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 15*s.* net.]

Department of Scientific and Industrial Research. Current Meters for Use in River Gauging. By M. A. HOGAN, Ph.D., D.I.C. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* 7½*d.* post free.]

Forschungsarbeiten auf dem Gebiete des Ingenieurwesens Heft 246. *Beschaffenheit des Flusseisens für gute Schmelzflammen-Schweissung.* Von Dr. Ing. e. h. C. DIEGEL. [Price 60 marks.] Heft 248. *Untersuchungen über laminare und turbulente Strömung.* Von Dr. L. SCHILLER. [Price 30 marks.] Heft 253. *Untersuchungen an Kondensations-Luftpumpen.* Von Dr. Ing. K. HOEFER. [Price 60 marks.] Heft 255. *Der Kreisträger.* Von GEORG UNOLD. [Price 40 marks.] Heft 256. *Untersuchungen an Dampfstrahapparaten.* Von Dr. techn. F. HEISL. [Price 20 marks.] Heft 260. *Beitrag zur Berechnung der Dampfturbinen auf Zeichnerischer Grundlage.* Von Dr. Ing. ERICH HENNE. [Price 40 marks.] Berlin: Verlag des Vereines deutscher Ingenieure und Julius Springer.

North-East Coast Shipping Who's Who 1922. Liverpool: *Journal of Commerce.* [Price 2*s.*]

INDUSTRIAL NOTES.

THE Ministry of Labour state that employment during July, though still bad generally, showed a further slight improvement as compared with June. In the textile trades and in the tin-plate and steel sheet trades the improvement previously reported was maintained, and there was also some improvement in the coal-mining industry and in the engineering and shipbuilding trades. The percentage unemployed among members of trade unions from which returns are received was 14·6 at the end of July, as compared with 15·7 at the end of June, and 16·7 at the end of July, 1921. The percentage unemployed among workpeople insured under the Unemployment Insurance Act was 12·3 on July 24, as compared with 12·7 on June 26. The total number of workpeople registered at the Employment Exchanges as unemployed on July 31, was approximately 1,400,000, of whom 1,151,000 were men and 170,000 were women, the remainder being boys and girls. At the end of June the number on the Live Register was 1,455,000, of whom 1,206,000 were men and 177,000 were women. The number of vacancies notified by employers to Exchanges and unfilled on July 31 was 14,100, of which 2,800 were for men and 9,200 for women, compared with 16,500 on June 26.

In the industries and services for which statistics are compiled by the Labour Department the changes in rates of wages reported as having taken effect in July resulted in a total reduction of nearly 490,000*l.* in the weekly full-time wages of over 2,360,000 workpeople and in an increase of nearly 13,000*l.* in the weekly wages of nearly 330,000 workpeople. The principal reductions affected coal miners in Yorkshire and the East Midland area, workpeople employed in the engineering industry generally, and railway servants. In the case of coal miners in the above area there was a decrease of over 6 per cent. on current rates; engineers had their wages reduced by 5*s.* 6*d.* per week; and the wages of railway servants in most grades, except engine drivers and firemen, were reduced by amounts varying from 2*s.* to 4*s.* per week. The principal increases affected coal miners in Durham, whose rates of wages were raised by less than 1 per cent. on current rates, and brass workers at Birmingham and workpeople employed in the textile bleaching, dyeing, printing, &c., trades, who received small increases under "cost of living" sliding scales. Since the beginning of 1922 the changes in rates of wages reported to the Department have resulted in a net reduction of nearly 3,200,000*l.* in the wages of 7,350,000 workpeople, and a net increase of nearly 3,500*l.* in the wages of 18,000 workpeople.

The number of trade disputes involving stoppages of work reported to the Department as beginning in July was 21. In addition, 36 disputes, which began before July, were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in July (including those workpeople thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 46,000, as compared with 310,000 in the previous month, and 1,140,000 in July, 1921. The estimated aggregate duration of all disputes during July was nearly 450,000 working days, as compared with 2,100,000 days in June, 1922, when a general dispute in the engineering industry was in progress, and 5,000,000 days in July, 1921, the figures for which month include days lost owing to a general dispute in the coal-mining industry.

On August 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was about 81 per cent. above that of July, 1914, as compared with 84 per cent. on July 1.

Speaking at the conference of the National Federation of General Workers which was opened in the Town Hall, Leamington, last week, Mr. J. R. Clynes, M.P., said it was not a good thing for the social and industrial prosperity of the country "that employers should take advantage of the helplessness of workmen, when the state of the labour market aided them, in forcing big wage reductions." Advances in wages, he added, were very gradual during the years of war, and so far as trade conditions required new wage rates, "they should be arranged with a reasonable and humane relation to a substantial reduction in the cost of living." We find it very difficult to believe that Mr. Clynes is really convinced in his own mind of the correctness of his remark concerning the employers basing wage reductions upon the helplessness of their employees. As regards the high cost of living, many causes come into play which make for this. In this connection we may add that even a cursory glance at shops and

markets on the busy days suffice to show that manual workers readily purchase articles which other members of the community, considered generally as being better circumstanced, are unable to afford. Mr. Clynes further stated that the settlement (with Germany) should be based upon the ascertained capacity of that country to pay, "without the cheap products of her people recoiling upon the trades of this country and producing the twin evils of reduced wages and unemployment." We greatly welcome the proviso; it seems to suggest the fact that Mr. Clynes, after carefully studying the particular situation, has arrived at a solution of the difficulty he outlines. Would he state his solution?

The following figures of costs of production and proceeds per ton of coal disposable commercially during the quarter ended on March 31, 1922, have been issued by the Board of Trade. The figure for wages, not including the subvention payments made during the quarter ended September, 1921, from moneys provided by Parliament, but including the subsistence allowances paid in subsequent periods to low-paid day wage workers, was 13*s.* 4·08*d.* That for stores and timber 2*s.* 6·99*d.* Other costs (management, salaries, insurances, repairs office, and general expenses, depreciation, &c.) were 3*s.* 2·02*d.* Miners' Welfare Fund contributions, 1·10*d.* Royalties (including the rental value of freehold minerals where worked by the proprietor) amounted to 0*s.* 7·47*d.* Total costs, 19*s.* 9·66*d.* By deducting the proceeds of miners' coal, 0*s.* 1·38*d.*, the total net costs become 19*s.* 8·28*d.* The proceeds of commercial disposals being 20*s.* 9·90*d.*, the credit balance is 1*s.* 1·62*d.* only.

It is reported that the Edward Pit of the Wallsend and Hebburn Coal Company has been laid idle, the men having stopped work. The trouble is said to have arisen following upon the irregular working of several of the miners who had received their notice in consequence. The Stanton Ironworks Company have given notice to their men employed at the Silver Hill Colliery to the effect that this is to be closed until such a time as the situation in the coal trade justifies its reopening. The company state that since the war the colliery has been worked at a material loss, partly due to the condition of the coal trade, but largely to the various increases in wages given during the period of the war. The directors are unable to bear the loss involved. They would not close the colliery if the men would assist them in trying to operate it without loss.

Following several conferences between the employers on the North-East Coast interested in the shipment of coal, and representatives of the transport and railway workers, an agreement was arrived at last Saturday, which states:

"That as and when required, the second shift shall work on Mondays to Fridays inclusive not exceeding two hours' overtime, and such overtime shall be paid at an agreed wage per hour for each hour or part of an hour of overtime. The trimmers and teamers working at the place shall be consulted with a view to agreeing a reasonable notice in regard to such overtime. The rate agreed for overtime during the experimental period to October 31 is to be 2*s.* per hour (less 8½ per cent.). It is specifically agreed: (1) That the overtime hereby agreed is to be without prejudice to the question of remuneration for the third shift when and where such may hereafter be worked. (2) That at any staithe or shipping places where a third shift is not hereafter by the tribunal agreed to be worked, the arrangements may be continued by mutual agreement between the parties. The employers shall, however, be at liberty at such places to reopen the question of a third shift at a later date.

"In the first week in November, 1922, there shall be a resumption of this conference of the parties concerned to examine the effect of this experiment to cope with the traffic; and if, after examination of the data supplied, it is held by the employers that a third shift is still necessary at any point to cope with the traffic at such point, and the parties not being able to agree, then the matter shall be referred without delay for determination to a tribunal consisting of three persons—one person, who shall be the chairman, to be nominated by the Minister of Labour; one person to be nominated by the employers; and one person to be nominated by the representatives of the workmen, with power to determine under the agreement of March 26, 1919: (1) Whether and where, if at any places, the third shift shall be worked. (2) What shall be the extra rate, if any, to be paid to the trimmers and teamers working such third shift."

Coal and Refractories in the Malay States.—The Malayan collieries produced 299,351 tons of coal in 1921, an increase of 51,434 tons over the previous year. The total amount produced from these mines since mining operations commenced is 1,175,950 tons.

EXPLOSION OF A STOP VALVE CHEST AT A SPINNING MILL.

A formal investigation has been made by the Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the cause and circumstances of an explosion of a cast-iron steam stop valve chest which occurred on December 28, 1921, at the Denholme Mills, near Bradford, Yorkshire, owned by Messrs. W. and H. Foster, of that address, by which explosion two men were killed and two others were severely scalded but subsequently recovered.

The investigation was held on April 5, 1922, at the Town Hall, Bradford, when Mr. George C. Vaux appeared for the Board of Trade, and Mr. Jonathan Knowles, solicitor, appeared for Messrs. W. and H. Foster, Limited, the owners, and Mr. Hartley Wood, the company's engineer, and Mr. A. E. Hartley, solicitor, on behalf of Boltons Superheaters, Limited, which firm fitted up the new line of piping.

In the report issued by the Board of Trade, Messrs. A. B. Bence-Jones and Arthur J. Maginnis, engineer surveyors to the Board of Trade, state the body of the stop valve was ellipsoidal in form, with an inlet and an outlet branch, each of 9 in. bore and having flanges 15½ in. in diameter by 1¼ in. thick. The overall length of the chest over these flanges was 28½ in. The valve was of the ordinary screw-down type, with a gun-metal valve and seat. There was a third branch from the bottom of the body, 8 in. in bore and having a flange 14 in. in diameter by 1¼ in. thick. This branch was in free connection with the inlet branch, and to it was jointed a drop leg 8 in. in diameter by 2 ft. 9½ in. deep. An automatic steam trap drained through a cock of 1 in. bore from the bottom of the drop leg.

The stop valve was not insured, and no regular inspection appeared to have been made.

The report states that the stop valve which exploded was made by Messrs. Pollitt and Wigzell, Limited, of Bank Foundry, Sowerby Bridge, in 1899, and was, therefore, about 23 years old. It was situated in that part of the works known as the New Mill, where there were three Lancashire boilers which worked at a pressure of 160 lb. per square inch. At the time of the explosion, however, the safety valves were only loaded to 100 lb. The boilers were used to supply steam to two main engines placed in one room, and also to a combing engine placed in its own room.

In December, 1921, the owners decided to substitute for the range of cast-iron piping a new range of solid drawn steel pipes in consequence of the increase of the working pressure. This work was commenced on December 23, and finished about 2 p.m. on the 27th. The new range was horizontal for a distance of about 80 ft., with a slight drop from the boilers. There was then a drop vertically for a distance of about 23 ft., while a branch pipe, 4 in. in diameter, dropped from the vertical leg to the combing engine. This branch was 67 ft. long. At the foot of this vertical leg the main branch divided into two parts, one, 9 in. in diameter, leading to the stop valve which burst, the other, 8 in. in diameter, leading to the other stop valve. The only drains on the range were three automatic steam traps, and up to the time of the explosion they worked well and gave no trouble. The manipulation of these traps was left to John Bryden, one of the engine tenders, who was accustomed to the work.

Shortly after 2 p.m. on December 27, after the work of putting up the new steam pipe range had been completed, a steam trial was made by running each of the three engines, without load, for a period of about five minutes separately. Orders were given to Bryden to see that the automatic steam traps were well-slacked back before steam was put on, and a large amount of steam was seen issuing under the engine room platfrom during the trial. The combing engine ran its trial last, and before the trial was concluded Mr. William Garnett Foster went into this engine room and noted much steam escaping below. He saw Bryden close something which stopped this escape of steam. The trials proved satisfactory, the pipes and joints being found sound and tight. After the trials the engines were stopped by closing the engine valve, but the boiler stop valves were left open, leaving the pressure on the range of pipes. This was usual at the mill. These trials concluded about 3.45 p.m., and at about 5 p.m., work was finished for the day. Alfred Bryden, another engine-room tender, left the engine room about 4.45, and was the last to go. He did not interfere with the adjustment of the steam traps. About 7 a.m. on the 28th the engine tenders and millwrights got the machinery ready to start work at 9 a.m. John Bryden was the first to arrive, and found the steam pipes quite cold. Alfred Bryden arrived a few minutes later, and both went to the top of the engine house, lit the gas there and felt the stop valves, and found both were cold. John told Alfred to fetch one Bancroft, the works mechanic, who arrived in a few minutes. By that time John had proceeded under the engine room platform, and Bancroft climbed down to join him and almost at once the noise of water surging in the steam pipes was heard three times. The branch of the 9-in. stop valve to which the leg was attached, broke away from the chest, and an irregular piece about 12 in. in size was forced out of the side of the body. In addition the bridge of the other stop valve was fractured across the middle. John Bryden, below the floor, and Edwin Kershaw, a loom mechanic, who was on the engine floor, were killed by the escaping steam, and W. H. Bancroft and W. Bolton, a yard labourer, were scalded, but, as previously stated, subsequently recovered.

With regard to the cause of the explosion, Messrs. Bence-Jones and Maginnis state this was undoubtedly due to water-hammer, and was another instance of this only too frequent occurrence when starting to heat up machinery in preparation for work. In this case they came to this conclusion partly by reason of the fact that the very cold weather which prevailed during the night acting on the bare unlagged pipes, charged the long range of pipes with water due to condensation. On the morning of the explosion, when the men were arranging to heat up and start work, the boiler pressure was 90 lb., and in some way which the evidence failed to indicate clearly, this high pressure through the pipes draining, reached the burst stop valve, and there meeting with a considerable area of dead cold water in the leg branch, at once set up violent water-hammer, as is clearly indicated by the three heavy "bangs" spoken of by the witnesses. Careful examination of the witnesses failed to elucidate how this draining came about, and owing to the unfortunate death of Bryden, it was impossible to ascertain whether he altered the trap to allow of its flowing more freely.

With regard to the responsibility, the report states from the evidence it was clear that Bryden was in the pit for so short a time before the explosion that he practically could not have altered the automatic trap, and in the absence of evidence to that effect he was exonerated from blame, nor was such blame fixed on any other of the staff or the management. Though not the immediate cause, there was no doubt that if the stop valves on the boilers had been closed after the trial on the evening of the 27th, it was more than probable that the explosion would not have occurred. But in these circumstances blame was not attributed to either Mr. W. G. Foster or to Mr. Hartley Wood, the company's engineer.

The following questions, which were submitted by Mr. Vaux on behalf of the Board of Trade, were then dealt with:—

Question 1.—"When was the steam range of which the exploded stop valve casting formed a part fitted up at the Denholme Mills?"

Answer.—"In December, 1921, a few days before the date of the explosion."

Question 2.—"Was the arrangement of the pipes a satisfactory one, and were the automatic steam traps provided for draining them sufficient and in good order?"

Answer.—"The reply to both these questions is in the affirmative."

Question 3.—"Were the valves of the automatic steam traps left open on the evening of December 27 last when the employees left the mill?"

Answer.—"Yes."

Question 4.—"Before the explosion occurred had the employees at the mill or any of them been warned by the owners or by Mr. Hartley Wood, their mill engineer, of the danger of attempting to drain steam pipes containing cold water while such pipes were under pressure and in open connection with the boilers supplying it?"

Answer.—"Yes, by Mr. Hartley Wood, the mill engineer."

Question 5.—"What was the cause of the explosion of the stop valve on the morning of December 28, last?"

Answer.—"Water-hammer brought about by reason of the fact that the automatic trap permitted the water to drain away from the range of pipes, so allowing the high pressure steam to reach the cold water at the burst stop valve."

Question 6.—"Are Messrs. W. and H. Foster, Limited, and Mr. Hartley Wood, their mill engineer, or is either, and if so, which of them, to blame for the explosion? Should they or either of them pay any, and if so, what part of the costs of this formal investigation?"

Answer.—"The answer to both these questions is in the negative, and we make no order as to the costs of this formal investigation."

Concluding their report, Messrs. Bence-Jones and Maginnis were of the opinion that owners, managers, and engine tenders should use the widest endeavours to adopt such a system of steam pipe drains and careful working of stop valves as will obviate heavy accumulations of water. It would be well if attention were specially drawn to water-hammer accidents, and so directed that the steam users would draw up brief and simple rules for the guidance of engine tenders and their supervisors. It should be insisted that such rules should be posted at places where they can be easily read. The report closed with thanks to Mr. Vaux for the very fair way in which he had conducted the inquiry, and acknowledgments to Mr. Jonathan Knowles and Mr. W. G. Foster for the assistance they had given. Expressions of deep sympathy were also expressed with the relatives of those who had lost their lives.

A New Mechanical Puddling Process.—A recent issue of the *Iron Age* described a new method of producing mechanically-puddled iron which is being worked by the Titan Iron and Steel Company, Inc., of Newark, N.J., U.S.A. In this system the iron is puddled in a cylindrical chamber lined with refractory, and supported with its axis horizontal, by two large diameter hollow trunnions, on roller bearings. The interior of the chamber is fitted with a fin or dam projecting from the lining towards the centre. The charge is admitted through one hollow trunnion, and an oil burner is arranged in the other, directing its flame down on to the metal. The cylinder is rocked so that the charge falls over the dam and then back again on the reverse. After a while the ball begins to form and the cylinder is then revolved instead of rocked, the ball being finally discharged through a door on to a conveyor which carries it to a rotary squeezer, which transforms it into a bloom suitable for the roughing mills. The squeezer consists of a corrugated drum revolving to one side of an horizontal trough so that the size of the space gradually diminishes from the feeding to the discharge side.

TESTS OF A 60,000-KW. CROSS-COMPOUND TRIPLE-CYLINDER STEAM TURBINE.*

By HERBERT B. REYNOLDS and WALTER F. HOVEY, New York, N.Y., Associate Members.

A PAPER was presented before the society† by H. G. Stott and W. S. Finlay, Junior, in 1916, which reported the results of a series of tests on a 30,000-kw. Westinghouse cross-compound turbine. This turbine was one of three which were installed at the 74th-street Power Station in order to provide additional power capacity for the new subways constructed in New York City during the period from 1913 to 1921 and operated by the Interborough Rapid Transit Company. Soon after the completion of these three turbines work was started on the installation of three 30,000-kw. General Electric turbines at the 59th-street Power Station, while the installation of a 60,000-kw. Westinghouse cross-compound triple-cylinder turbine was started at the 74th-street Power Station.

A paper was presented before the society at the spring meeting in 1921 which reported the results of the tests on one of the General Electric turbines mentioned above, while the present paper contains the results of the tests on the 60,000-kw. Westinghouse unit installed at the 74th-street Power Station.

Fig.1. PLAN VIEW OF TURBINE AND AUXILIARIES

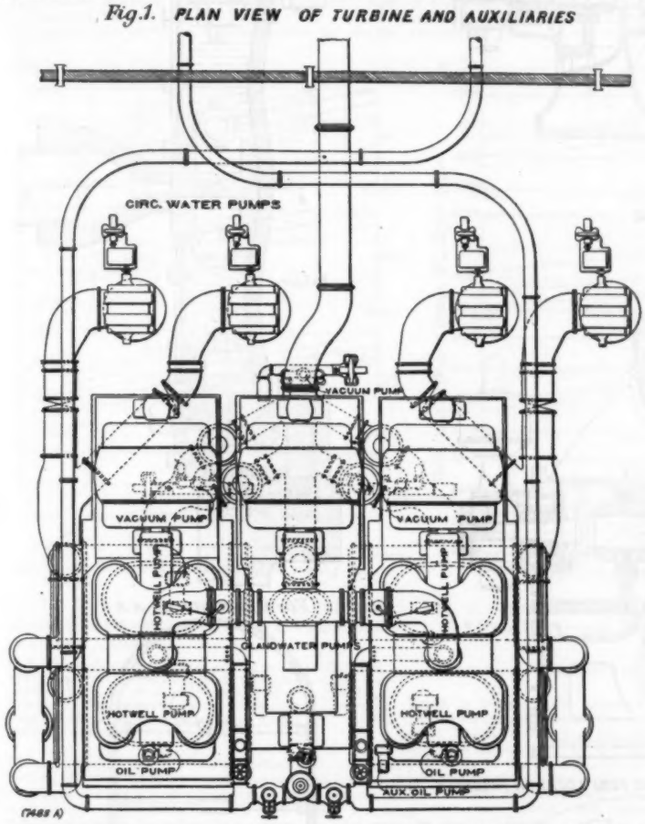


Fig.2. END ELEVATION OF TURBINE AND CONDENSERS WITH RIGHT HAND SIDE BROKEN AWAY TO SHOW EXPANSION JOINT

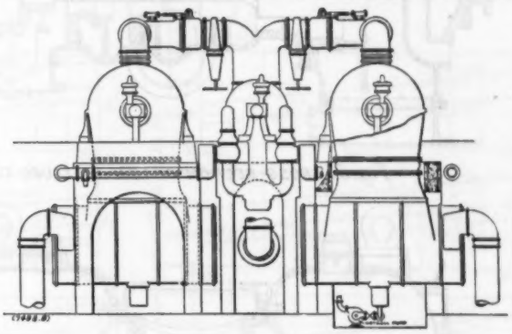
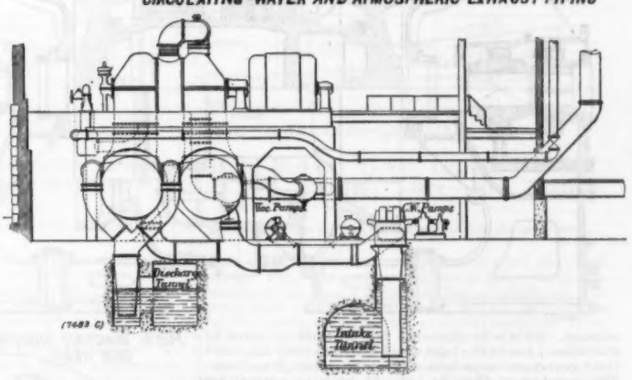


Fig.3. SIDE ELEVATION OF TURBINE AND CONDENSERS SHOWING CIRCULATING-WATER AND ATMOSPHERIC EXHAUST PIPING



The engine-room at the 74th-street Power Station originally contained eight 7,500-kw. Allis-Chalmers double angle-compound engine units of the well-known Manhattan type and similar to the engines which were later installed in the 59th-street Power Station. During 1905 a 5,500-kw. Westinghouse turbine was installed, the capacity of which was subsequently increased to 8,000-kw. by re-winding the generator. In order to provide space for the three 30,000-kw. Westinghouse turbines, the installation of which was completed in 1915, it was necessary to remove four of the Manhattan engine units.

A fifth engine unit was removed in 1916 in order to provide space for the 60,000-kw. unit, the installation of which was completed in 1918. It will thus be seen that the 74th-street engine-room equipment consists of three 30,000-kw. cross-compound, two-cylinder Westinghouse turbine units, one 60,000-kw. cross-compound, three-cylinder Westinghouse turbine unit, three 7,500-kw. Manhattan type Allis-Chalmers double angle-compound engine units, and one 8,000-kw. Westinghouse turbine unit.

The Turbine Unit.—The arrangement of the 60,000-kw. machine is shown in Figs. 1 to 3. The turbine is of the cross-compound triple-cylinder type, consisting of one high-pressure element and two low-pressure elements, each element driving a separate generator. Fig. 1 shows the arrangement of the turbine in plan together with the auxiliaries, while Figs. 2 and 3 show the front and side elevations.

The normal steam pressure at the throttle is 220 lb. absolute with a superheat of 150 deg. F. exhausting into a vacuum of 29 in. Hg. referred to a 30-in. barometer at 58·1 deg. F. The speed of all three elements is 1,500 r.p.m. In Fig. 1 it will be seen that steam is supplied to the unit through two steam lines, each one of which is provided with a throttle. After passing through the throttle the steam enters a common chamber. The use of two small lines gives greater flexibility and increases the reliability somewhat. A cross-section of the high pressure element is shown in Fig. 4. It will be seen that this element is of the single-flow straight reaction type having a total of 25 stages. In addition to the primary steam inlet which takes care of all loads up to 40,000 kw., secondary and tertiary inlet connections are provided. The secondary inlet by-passes the first six stages and is opened automatically by the governor at a load of approximately 40,000 kw. This secondary inlet takes care of all loads up to 50,000 kw., after which the tertiary inlet, which by-passes the first 10 stages, opens and increases the capacity to 60,000 kw. The generators are able to carry a maximum load of 70,000 kw. for 2 hours. In order to carry this load, a hand-operated quaternary valve has been provided which by-passes four additional stages. After passing through the high-pressure element the steam is exhausted through the connection shown on top of the casing. The connection shown at the bottom is for an atmospheric relief valve which has not been installed.

The steam is led to each low-pressure turbine through the large pipes shown on top of the turbines in Figs. 1, 2 and 3. Fig. 5 shows a cross-section of the low-pressure turbines, which are of the semi-double flow type. The steam enters through the top of the casing and passes through a single-flow element consisting of 10 stages. After passing through this intermediate section the steam divides and passes through two low-pressure sections, each containing six stages, after which it is discharged to the condenser.

All glands are water-sealed during regular operation, the water supply being obtained from the condensate. While starting, steam is used for sealing the glands. A self-contained lubricating system is provided. The oil is circulated through the coolers and bearings by means of three pumps, one connected to each turbine shaft. In addition to these pumps, two duplex steam-driven oil pumps are provided for starting and emergency service. These two emergency pumps are controlled automatically by floats in an elevated oil tank. The unit is provided with a number of automatic features which makes it possible for any one of the three elements to go out of service and allow the remaining elements to remain on the line to take care of the load. It has not been possible to make full use of these automatic features up to the present time, due to the absence of a relief valve on the exhaust of the high-pressure turbine.

Each low-pressure element is provided with a live steam connection and a governor adjusted for a wide regulation, approximately 12 per cent., while the governor on the high-pressure unit is adjusted to a close regulation. The governor on each low-pressure element will in the outer part of its travel close a butterfly valve in the line between the high-pressure and low-pressure turbines. These butterfly valves may be seen in Fig. 2. When these governors reach the inner positions they begin to admit and regulate high-pressure steam to the low-pressure turbines. There is a zone between these two positions in which the motion of the governor has no effect. This zone is sufficiently wide to cover the total speed variation of the machine when operating normally so that the low-pressure governors have no function to perform during normal operation.

In order that the switchboard operator may keep the low-pressure governors in the middle of the neutral zone, a remote indicating system is provided which gives an indication on the switchboard of the exact position of these governors.

Each element is provided with a stop governor which closes the automatic throttle admitting live steam to the low-pressure turbine and the butterfly valve admitting low-pressure steam to the low-pressure turbines only, while the automatic stop governor on the high-pressure will close the main automatic throttle valve only. There is a switch arranged in connection with each of the three automatic throttle valves so that when the automatic throttle valve operates, this switch opens the oil switch of whichever turbine element is involved.

As mentioned before, the exhaust of the high-pressure turbine is to be provided with a relief valve which, in the event of one of the low-pressure turbines being thrown out of service by the closing of the butterfly valve, will permit the surplus exhaust steam to escape to the atmosphere. This valve will be set to that pressure corresponding to the maximum load on one of the low-pressure turbines which the generator can sustain without injury for a brief period.

The automatic features described above will take care of the following emergency conditions:—

(*a*) If the oil switch to one low-pressure generator is opened, that element will speed up until the low-pressure governor comes into action and closes the butterfly valve in the low-pressure steam inlet. The turbine will then slow down until the governor travels to its other extreme position when the live-steam connection will open and keep the turbine running until shut down by hand. In the meantime the load on the high-pressure and remaining low-pressure turbine will be increased due to the loss of one low-pressure. All of the steam from the high-pressure will endeavour to pass through the remaining low-pressure, which may be overloaded in the absence of the relief valve, which will limit the steam pressure and thus the load which may be applied to the low-pressure turbine. The capacity of the high-pressure and one low-pressure, when operating in this manner, is approximately 35,000 kw.

(*b*) If one of the low-pressure turbines speeds up and

* Paper read before the New York Section of the A.S.M.E., February, 1922.

† Trans. Am. Soc. M.E., vol. xxxviii, page 655.

knocks out the safety trip the butterfly valve will close, the live steam connection will be prevented from opening, and the oil switch to the element involved will be opened, all of which will permit the element to come to rest.

(c) If the oil switch to the high-pressure element is opened this element will tend to speed up, which will cause the high-pressure governor to reduce the supply of steam passing through the throttle to a very small amount. This will cause the low-pressure turbines to slow down, due to the load which they are carrying, until their governors come into action and admit live steam. The speed may then be brought back to normal by adjusting the low-pressure governors.

(d) If the automatic stop governor on the high-pressure turbine is knocked out due to overspeed, the oil switch to this element will open allowing it to come to rest. In the meantime the low-pressure governors will come into action and open the high-pressure steam connections to the low-pressure turbines so that they will continue to carry load, the capacity of each low-pressure turbine being approximately 23,500 kw.

Pending the installation of the relief valve, it is impossible to take advantage of these various features. In order to prevent any damage which may result from the closing down of any one element, the overspeed trips are tied in together so that if any one element knocks out its stop governor, the entire unit will be shut down. One of the low-pressure elements is provided with a heat balance connection through which any excess auxiliary steam may be injected. The generators are three-phase star-connected, generating 25-cycle current at 11,000 volts. Excitation current is furnished at 250 volts. The generators are cooled by a circulation of air maintained by a fan which forms an integral part of the generator. The air is drawn from the turbine room basement and discharged from the top of the generator into the turbine-room through a short chimney-stack. Each generator is connected through an oil switch to a short 'bus-bar, which 'bus in turn is connected to the station 'bus through another oil switch. This arrangement permits all three generators to be brought up to speed and synchronised simultaneously.

Condensers and Auxiliaries.—The condensing equipment for each low-pressure turbine consists of a two-shell, two-pass Westinghouse condenser, two Westinghouse centrifugal circulating pumps each driven through reduction gears by Westinghouse turbines, and two Westinghouse centrifugal condensate pumps, each driven by a Westinghouse turbine. The entire unit is served by three Le Blanc air pumps.

Each condenser shell contains 25,000 sq. ft. of tube surface made up of 5,300 tubes, 18 ft. long, 1 in. outside diameter and of No. 18 B.W.G. thickness. A portion of the tube surface next to the turbine exhaust amounting to 1,200 sq. ft. is used as a preheater through which the condensate is circulated. Fig. 6 shows the arrangement of the condenser tubes. Each condenser is provided with two relief valves. The reason for using two small valves instead of one large valve is that these valves were available from the old engine units. Each circulating water-pump is capable of delivering 28,000 gallons of water against a total head of 20 ft. The turbines which drive these pumps operate at 3,600 r.p.m., which speed is reduced to 360 r.p.m. through Westinghouse gears. Each condensate pump is capable of delivering approximately 1,000 gallons per minute against a discharge head of 40 ft. The turbine and pump both operate at a speed of 1,600 r.p.m.

The air pumps are of the well-known Le Blanc type operating at 2,500 r.p.m. They receive their hurling water from the discharge of the circulating-water pumps. In order that the air leakage may be checked from time to time, connections have been made to a rotative dry vacuum pump, belonging to an adjacent unit, which can be discharged into a gasometer.

Foundations.—Each element is mounted on a separate structural steel foundation encased in concrete. The condensers are hung from these foundations by steel straps bolted to pads on the upper part of the condenser shells. In view of this rigid mounting it was necessary to install a large rubber expansion joint between the turbines and condensers. This joint is shown in Figs. 7 and 8. It will be noticed that water protection has been provided so as to protect the rubber from the high temperature during the starting-up periods. Rubber expansion joints are also provided in the circulating water lines. Copper expansion joints are inserted in the steam lines between the high and low-pressure turbines and also in the atmospheric relief lines.

(To be continued.)

Fig. 4. CROSS-SECTION OF HIGH-PRESSURE-TURBINE

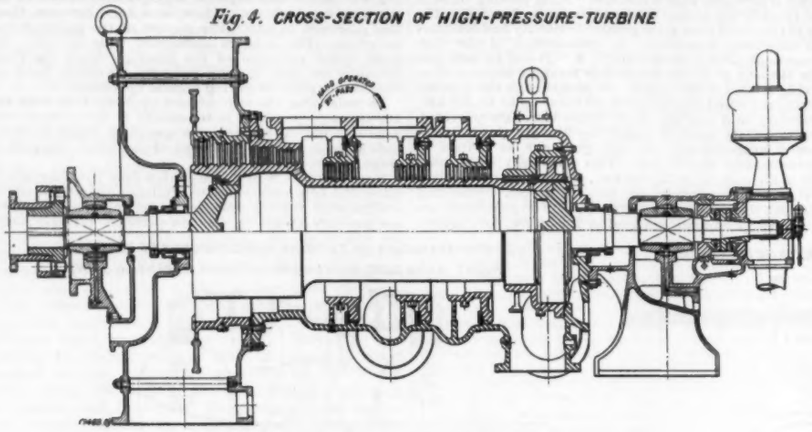


Fig. 5. CROSS-SECTION OF LOW-PRESSURE TURBINE

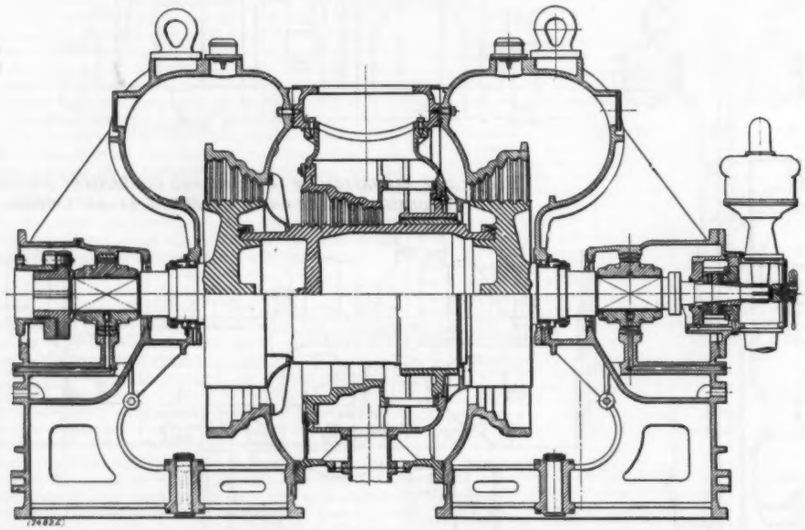


Fig. 6. DIAGRAM SHOWING TUBE LOCATION IN CONDENSER HEAD

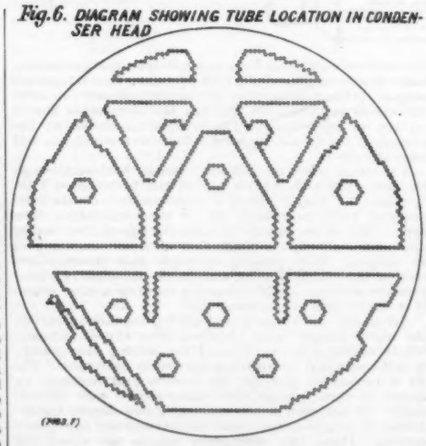


Fig. 7. DETAIL OF RUBBER EXPANSION JOINT

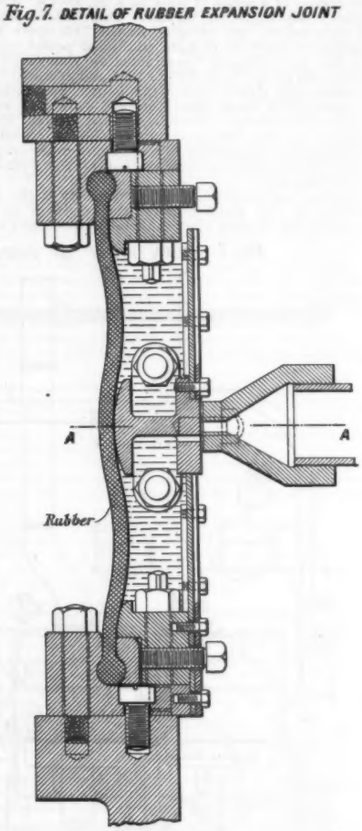
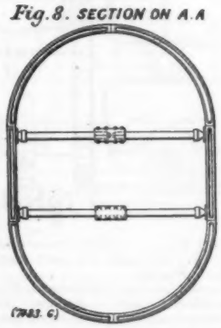


Fig. 8. SECTION ON A.A



French Railway Tariffs.—The Administrative Council of the French Railways met on the 10th inst., in order to examine a number of railway tariffs bearing upon the general economics of the country and particularly upon the cost of living. Among the tariffs gone into were those which are applicable to coal, coke and minerals, important reductions in which are contemplated. The tariffs covering liquid fuels of all kinds are also being investigated with a view to revision.

TENSILE PROPERTIES OF STEEL CASTINGS.*

By LAWFORD H. FRY.

THIS paper puts on record the results of nearly 600 tension tests representing steel castings of the grade currently used in locomotive construction. The tests were made by a group of manufacturers of steel castings as a contribution to the work of the A.S.T.M. and A.R.A. Joint Committee on Specifications for Steel Castings. It was thought that information thus collected would afford a proper basis for a study of the tensile properties to be expected in steel castings for locomotives. Information regarding the proper method of measuring the tensile properties was also sought. The data were collected and reported on by a committee of which the writer was chairman, the other members being Messrs. H. M. Lewis, Pratt and Letchworth Company; C. N. Ring, Ohio Steel Castings Company; J. V. R. Stehman, Birdsboro' Steel Foundry and Machine Company; and J. L. Uhler, Union Steel Casting Company. Experiments were also made and reported by Messrs. J. C. Davis, American Steel Foundries; G. T. Johnson, Buckeye Steel Castings Company; and B. C. Bakewell, Duquesne Steel Foundry.

The programme given to the committee in charge of the work called for: (1) The collection of information regarding the tensile properties of steel castings furnished for railroad service; and (2) accurate measurement of the relation between extension and load during tension testing, particular attention being given to the true elastic limit.

To meet this programme, those interested were requested to carry out the two series of experiments which are described in detail below under the headings "Running Tests" and "Precision Tests." In the first series, or running tests, a pair of test coupons was taken from each of 200 castings. The first of the pair was pulled in the usual manner, while for the second the extensometer method adopted for heat-treated forgings by Committee A-1 on steel was used to determine the so-called elastic limit.† The information thus obtained shows (1) the tensile properties of castings furnished for railroad service; and (2) the relation between the yield-point and the elastic limit determined by the method of Committee A–1. In the second series of tests, the so-called precision tests, stress-strain curves were plotted using a Berry strain gauge to measure the elongation. The tension bars used were taken from special pads cast for the purpose, other bars being used to measure the tensile properties determined in the usual manner. Seven manufacturers co-operated, furnishing 40 pads representing 24 heats of steel.

In laying out the two series of experiments it was intended to have the running tests made under conditions equivalent to the best mill practice under railroad inspection, with the precision tests representing laboratory research conditions. Taking the two series of tests together, the following conclusions can be drawn:—

1. When two tension tests are made from a uniform steel casting the variation in the values found for the tensile strength is not usually in excess of 5 per cent. of the value of the tensile strength.

2. If a number of uniform bars are used, some to determine the yield-point and others to determine the elastic limit, the values of the yield-point are more uniform and more consistent than the values found for the elastic limit. It is evident that the value of the elastic limit is more dependent on the personal equation of the observer and on accidental irregularities in the individual determinations. This is true whether the accelerated extensometer method of Committee A–1 is used or whether the elastic limit is measured from a stress-strain diagram as the proportional limit.

3. The uncertainty in the determination of the elastic limit is largely due to the fact which is shown in the majority of the precision tests, that there is no constant proportionality between elongation and stress. In other words the annealed cast steels investigated have no "true elastic limit," but behave as plastic rather than as elastic material.

4. The relation between elongation and tensile strength follows closely a hyperbolic law, that is to say tensile strength multiplied by elongation is a constant.

5. The relation between reduction of area and tensile strength does not follow a hyperbolic law as closely as is the case with the elongation. A fairly good approximation to the relation over a short range of tensile strengths is obtained by assuming that tensile strength multiplied by reduction of area is a constant. The value of the constant must, however, be less for high than for low tensile strengths.

6. When yield-point and elastic limit by the Johnson and Committee A–1 methods are determined for the same cast steel, greater variations in the individual values are found in the two latter than in the yield-point. If average values are taken, the relation is approximately as follows:—

	Per Cent.
Tensile strength	100
Yield-point by drop of beam	50
Elastic limit, A–1 method	45
Elastic limit, Johnson method	42

Detailed consideration of the experimental data follows.

RUNNING TESTS.

Method of Testing.—The programme laid out for these tests provided that each manufacturer should set aside from 50 to 100 bars from castings from which other bars had been originally taken for test in the regular course of business. The bars were to be marked so that the results from the duplicate bars could be compared with the results from the original bars. The original bars were to be tested by the usual method, the tensile strength, the yield-point by drop of beam, the elongation in 2 in., and the reduction of area being measured. The duplicate bars were to be tested in the presence of a railroad inspector appointed by Mr. F. Zeleny, chairman of the Sub-Committee on Methods of Testing of the Joint Committee of the A.R.A. and the A.S.T.M. The elastic limit was to be determined by a Berry strain gauge by the method adopted by Committee A–1 on Steel,* together with the tensile strength, the elongation and reduction of area. It was planned to measure also the yield-point as shown by the drop of the beam, but this was not found to be practicable in all cases.

Four manufacturers carried out the tests submitting results from a total of 396 bars representing 198 castings. The castings from which bars were taken included locomotive frames, driving wheel centres, and large miscellaneous castings. All of the castings were, as a result of the first test, accepted for railroad service. The castings were of acid and basic open-hearth steel with tensile strengths running from 60,000 lb. to 92,000 lb. per square inch and carbon from about 0·20 per cent. to 0·44 per cent. From the conditions under which the test bars were selected it is evident that they represent steel castings of good quality as currently accepted for railroad service.

EXAMINATION OF TEST RESULTS.

Tensile Strength.—The first step was to compare the tensile strengths of the two specimens from the same casting. Fig. 1 was prepared for this purpose, the tensile strength of the second specimen (T_2) on which the A–1 elastic limit was measured being plotted as ordinate over the tensile strength of the original specimen T_1 on which the yield-point was determined. If both specimens have the same tensile strength, the point will fall on the line $T_2 = T_1$. To facilitate comparison four other lines have been drawn; line $T_2 = 1{\cdot}05\ T_1$ marks a second specimen with a strength 5 per cent. and $T_2 = 1{\cdot}10\ T_1$ 10 per cent. above the first. The other lines correspond to second specimens with strengths respectively 5 per cent. and 10 per cent. below the first.

It is evident that in the majority of cases the variation between the two specimens does not exceed 5 per cent. Further, it will be noticed that in Fig. 1 (*a*) there is a tendency for the strength of the second specimen to be less than that of the first. It is probable that this is due to a lower testing speed having been used for the second specimens. Average tensile strengths for the tests from Works A covered by Fig. 1 (*a*) are given below together with testing machine speed:—

Style of Test.	Average Tensile Strength, Lb. per Sq. In.	Speed of Testing Machine, Inches per Minute.	
		To Yield-Point.	From Yield to Fracture.
First bar (drop of beam) ...	69,680	0·34	1·28
Second bar (A–1 elastic limit)	68,690	0·04	0·34

Yield-Point.—In Fig. 2, the values Y found for the yield-point by the drop of the beam are plotted in relation to the values T of the tensile strength for the same bars. The lines marked $Y = 0{\cdot}60\ T$, $Y = 0{\cdot}50\ T$, and $Y = 0{\cdot}45\ T$, show the position of points when the yield-point is respectively 60 per cent., 50 per cent. and 45 per

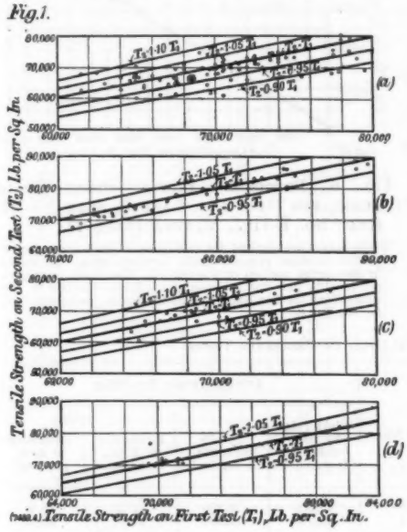


FIG. 1. RUNNING TESTS. RELATION BETWEEN TENSILE STRENGTH OF TWO SPECIMENS FROM THE SAME CASTING.

The four sections show tests from each of four manufacturers. The abscissæ T_1 are values of tensile strength from the first series of bars, in which yield-point by drop of beam was measured. The ordinates T_2 are values of tensile strength from the second series of bars, in which the "A–1" elastic limit was measured.

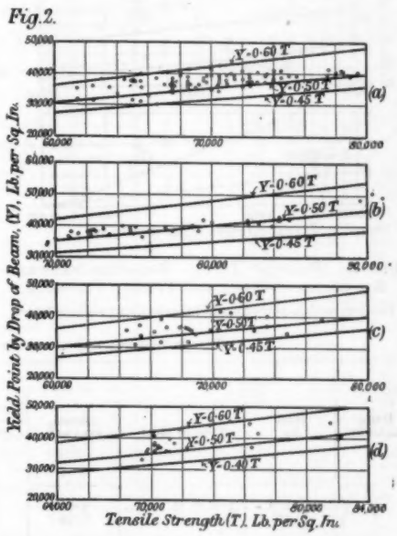


FIG. 2. RUNNING TESTS. RELATION BETWEEN YIELD POINT AND TENSILE STRENGTH.

The four sections show tests from each of four manufacturers.

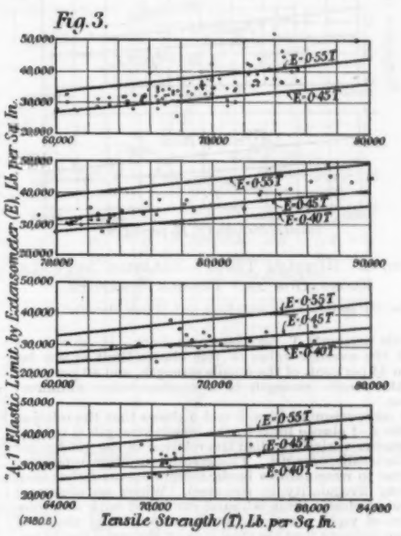


FIG. 3. RUNNING TESTS. RELATION BETWEEN "A-1" ELASTIC LIMIT AND TENSILE STRENGTH.

The four sections show tests from each of four manufacturers.

* Paper read before the American Society for Testing Materials, at Atlantic City, N.J., June, 1922.

† See Standard Specifications for Carbon-Steel and Alloy-Steel Forgings (Serial Designation: A 18-21), 1921, Book of A.S.T.M. Standards, page 148. The method is there described as follows: "The elastic limit called for by these specifications shall be determined by an extensometer reading to 0·0002 in. The extensometer shall be attached to the specimen at the gauge marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength."

* *Loc. cit.*

cent. of the tensile strength. It will be noticed that the relation between yield-point and tensile strength is generally quite uniform. Taking all tests, the yield-point averages very close to 50 per cent. of the tensile strength. Practically all of the castings show a yield-point in excess of 45 per cent. of the tensile strength.

Elastic Limit by Method of Committee A–1.—Values of this property E are plotted in Fig. 3 in relation to the tensile strength T for the same bars. It is evident that the average value of this elastic limit is not far from 45 per cent. of the tensile strength, and 40 per cent. of the tensile strength is a representative minimum value.

A comparison of Figs. 2 and 3 shows that the relation of the A–1 elastic limit to the tensile strength is subject to greater variations than the relation of the yield-point to the tensile strength. This greater variation appears to be due to irregularities in the measurements rather than to any irregularity in the steel. Where an abnormal value of elastic limit is found combined with a normal value of yield point, the other properties of the steel do not indicate that the steel is in an abnormal condition. In several cases the value found for the elastic limit is higher than that for the yield-point; this can only be accounted for by an error in observation. Determination of the A–1 elastic limit is made by observing the load corresponding to a sudden increase in the rate of motion of the strain gauge needle. This change in the motion of the needle is not always clearly marked, and in the decision as to the instant of its occurrence the personal equation of the observer is of importance.

The measurement of the yield-point by the drop of the beam is a simpler observation. With steel castings, the drop of the beam is well marked provided the machine is operated at a proper speed, and it is readily observed by both machine operator and inspector. The personal equation of the observer has less influence on the result than is the case with the A–1 elastic limit.

Elongation.—The values found for the elongation (measured in 2 in.) are plotted in Fig. 4 in relation to the tensile strength. As the values from both series of tests (yield-point and elastic limit) are plotted in this figure, there are two points for each casting. It is evident from the plot that there is a general relation between the values of elongation and tensile strength, but that no very exact law can be deduced. In Great Britain it is usual to assume that the relation follows a straight line law; for example, some of the British Standard Specifications require that the tensile strength in tons per square inch plus the elongation in per cent. shall be equal to a constant. This is the same as requiring

$$\text{Elongation} = \text{Constant} - \frac{\text{Tensile strength}}{2{,}240} \quad . \quad (1)$$

in which the tensile strength is expressed in pounds per square inch. In this country it is usual to assume that the relation follows a hyperbolic law of the form

$$\text{Elongation} = \frac{\text{Constant}}{\text{Tensile strength}} \quad . \quad . \quad . \quad (2)$$

With the present data available, an attempt was made to ascertain which form of law best fitted the relation. In each of the plots a straight line has been drawn with the equation:

$$E\,l = 64 - \frac{T}{2{,}000} \quad . \quad . \quad . \quad (3)$$

and a hyperbola with the equation

$$E\,l = \frac{1{,}600{,}000}{T} \quad . \quad . \quad . \quad (4)$$

The numerical coefficients for these equations were chosen with a view to placing the straight line so as to represent the average values, with the hyperbola to represent the minimum values. It is to be noted that the scales used for plotting the results are such that the hyperbola departs very little from a straight line. It is evident that there is little to choose between the two lines in their representation of the relation between elongation and tensile strength.

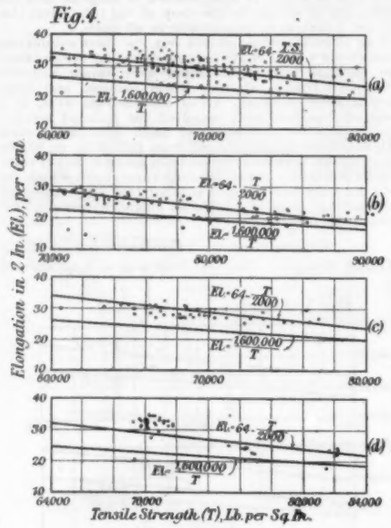


Fig. 4. Running Tests. Relation between Elongation and Tensile Strength.

The four sections show tests from each of four manufacturers.

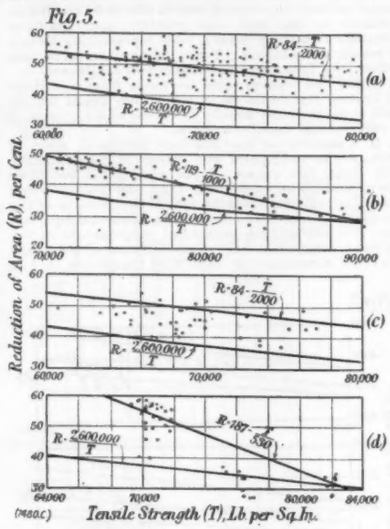


Fig. 5. Running Tests. Relation between Reduction of Area and Tensile Strength.

The four sections show tests from each of four manufacturers.

Reduction of Area.—The values for reduction of area are plotted in Fig. 5 in relation to tensile strength. As the values from both series of tests (yield-point and elastic limit) are plotted in this figure, there are two points for each casting. These plots are very similar to those for the elongation (Fig. 4) already discussed. Here also a hyperbola has been drawn to represent the minimum values, the equation being

$$R = \frac{2{,}600{,}000}{T} \quad . \quad . \quad . \quad . \quad (5)$$

Straight lines have also been drawn aiming at the average values. In Fig. 5 (*a*) a line with the equation

$$R = 84 - \frac{T}{2{,}000} \quad . \quad . \quad . \quad (6)$$

represents the mean position of the points fairly satisfactorily. In Fig. 5 (*b*), however, a more rapid slope is needed, the equation of the mean line being

$$R = 119 - \frac{T}{1{,}000} \quad . \quad . \quad . \quad (7)$$

In Fig. 5 (*c*) the same line as given by equation (6) gives fairly satisfactory results, though it is somewhat above the mean position, while for Fig. 5 (*d*) an even greater slope than that of Fig. 5 (*b*) is required, the equation being

$$R = 187 - \frac{T}{530} \quad . \quad . \quad . \quad (8)$$

It is evident that a single straight line equation of this form will not represent the relation between reduction of area and tensile strength. The hyperbola of equation (5) gives better results, though the corresponding values are somewhat high for the tensile strengths over 80,000 lb. per square inch, which occur in Figs. 5 (*b*) and 5 (*d*).

It is thought that the most satisfactory method of expressing the relation between reduction of area and tensile strength is to use a hyperbolic form of equation with a change in the numerical coefficient according to the range of tensile strengths to be covered. For example, reasonable minimum values are given by the equations which follow in the next column:

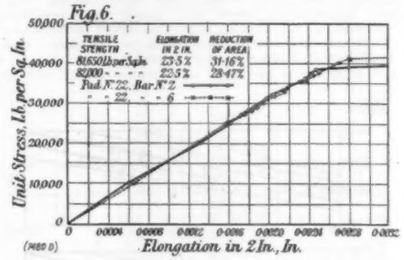


Fig. 6. Precision Tests. Stress-Strain Curve for Bars Nos. 2 and 6, Slab No. 22, Heat No. E-1192, Manufacturer D.

These curves are unusual for cast steel as they show almost perfect constant proportionality between stress and strain in the earlier portion of the curves. The break from proportionality puts the Johnson elastic limit at 38,000 lb. per square inch for bar No. 2 and at 39,500 lb. per square inch for bar No. 6.

Table I.—Properties of Steel Used in Precision Tests.

Manufacturer.	Heat No.	Type of Steel.	Carbon, per Cent.	Pad No.	Average Tensile Properties. Yield-Point by Drop of Beam, Lb. per Sq. In.	Tensile Strength, Lb. per Sq. In.	Elongation in 2 in., per Cent.	Reduction of Area, per Cent.
A	34,559	Acid O. H.	0·24	1 A	45,500	76,200	27·2	40·0
	34,577	,,	0·28	2 A	45,200	75,200	25·5	40·4
B	296 C	Acid O. H.	0·43	1 B	47,700	93,000	19·2	28·6
	313 C	,,	0·28	2 B	36,000	72,200	28·3	48·5
C	4,558	Acid O. H.	0·30	A	38,100	75,600	26·1	44·5
	4,558	,,	0·30	B	36,600	73,500	27·7	43·5
	4,574	,,	0·34	C	36,650	76,500	25·7	39·3
	4,574	,,	0·34	D	36,700	75,250	26·1	40·0
	4,436	,,	0·26	E	36,300	68,100	30·0	49·0
	4,436	,,	0·26	F	36,600	68,300	31·0	49·1
D	8,707–4	Basic O.H.	0·25	16	38,700	70,600	34·8	57·2
	8,707–4	,,	0·25	14	37,200	70,500	33·2	56·1
	8,693–4	,,	0·27	8	34,500	71,500	25·8	35·8
	8,693–4	,,	0·27	4	35,300	70,000	32·7	55·8
	8,154–3	,,	0·27	13	40,300	71,100	31·8	54·6
	8,154–3	,,	0·27	14	35,400	71,100	31·5	51·0
	9,159–1	,,	0·33	17	38,300	70,000	32·2	51·5
	9,159–1	,,	0·33	15	38,200	70,300	30·9	47·8
	E–1,192	Electric	0·35	22	42,500	81,300	21·4	31·7
	E–1,192	,,	0·35	25	40,000	82,100	23·0	32·5
	E–1,193	,,	0·33	18	38,900	76,600	24·3	39·5
	E–1,194	,,	0·31	19	44,500	76,000	24·0	34·0
E	1,144	Acid O. H.	0·24	1 E	37,300	67,600	32·4	53·0
	1,161	,,	0·26	2 E	36,400	67,400	33·7	54·6
F	37,825	Basic O. H.	0·29	1 F	39,300	74,400	27·8	47·6
	37,825	,,	0·29	2 F	—	73,100	31·4	54·5
	9,424	,,	0·25	3 F	35,500	65,800	36·3	59·6
	9,424	,,	0·25	4 F	—	66,200	32·5	57·6
	49,802	,,	0·24	5 F	35,700	67,750	33·1	60·3
	49,802	,,	0·24	6 F	—	67,900	34·1	59·6
	679	Acid O. H.	0·28	7 F	36,000	74,600	29·4	49·0
	679	,,	0·28	8 F	—	73,000	31·5	50·1
	7,244	,,	0·29	9 F	37,500	71,500	26·2	38·0
	7,244	,,	0·29	10 F	—	72,600	27·8	45·8
	836	,,	0·29	11 F	35,300	70,200	31·1	49·8
	836	,,	0·29	12 F	—	71,700	26·4	48·0
	114	,,	0·30	13 F	38,900	76,400	28·9	45·6
	114	,,	0·30	14 F	—	73,850	31·4	50·0
G	4,479	Acid O. H.	0·48	1 G	46,200	95,300	13·0	13·9
	4,492	,,	0·27	2 G	35,000	71,100	33·0	49·1

For low tensile castings :

$$\text{Reduction of area} = \frac{2{,}600{,}000}{\text{Tensile strength}} \quad . \quad . \quad (5)$$

For medium tensile castings :

$$\text{Reduction of area} = \frac{2{,}500{,}000}{\text{Tensile strength}} \quad . \quad (9)$$

For high tensile castings :

$$\text{Reduction of area} = \frac{2{,}400{,}000}{\text{Tensile strength}} \quad . \quad (10)$$

PRECISION TESTS.

Method of Testing.—The purpose of these tests was to measure accurately the relation between load and extension for cast steel of various grades made by a number of manufacturers, particular attention being given to determination of the elastic limit.

To furnish specimens, each manufacturer was requested to make two pads about 2 in. thick from each grade of cast steel currently made. Each pad was to carry 10 coupons on the pad ; the method of their removal and the gating and heading of the pads was left to the judgment of the manufacturers. After removal of a coupon from each end, the pads with coupons were to be annealed.

tensile strength and measuring the elongation and reduction of area.

Manufacturers were requested to plot the resulting stress-strain curves to uniform scales. Two different scales were chosen to show the effect of a change of scale on the results.

Results of Experiments.—Seven manufacturers co-operated, furnishing 40 pads representing 24 heats of steel, acid, basic and electric. The carbon content ranged from 0·24 per cent. to 0·48 per cent. and the tensile strength of the annealed material from 66,000 lb. to 95,000 lb. per square inch.

Table I shows the material furnished by each manufacturer and the average tensile properties. Details of the experimental methods of each manufacturer are given below :—

Manufacturer A furnished two pads, one from each of two heats of acid open-hearth steel. The test programme was followed.

Manufacturer B furnished two pads, one from each of two acid open-hearth heats, of 0·28 per cent. and 0·43 per cent. carbon respectively. In addition to the two programme curves from each pad, curves were drawn from the unannealed bars and from four other annealed bars. On two of the bars the yield-point was taken after the increment loading for the curves had been carried out.

carbon was not entirely satisfactory. The test programme was not followed strictly. Four bars from each pad were tested in the same manner. The testing machine was run at 0·03 in. per minute, and the Berry strain gauge readings noted as the specified loadings were passed. The proportional limit, Committee A–1 elastic limit, and yield-point by drop of beam were also noted. The speed of the machine was then increased to 0·125 in. per minute and maintained at this figure until fracture occurred. The machine was thus run without stopping during the test. Tests were also made in the same manner with 41 specimens from locomotive driving wheel centres and frames, and with eight specimens from similar castings using a speed of 0·125 in. per minute through the yield-point and stopping the machine at the load points. Curves were not plotted from the test figures.

Discussion of Results.—The stress-strain curves plotted from the various experiments afford data for a discussion of the so-called elastic limit of annealed cast steel. Representative curves are given in Figs. 6 to 8.

The term "elastic limit" has been so loosely used as to require definition as a preliminary to any discussion into which it is to be introduced. The American Society for Testing Materials, through its Committee E–1 on Methods of Testing, has defined "elastic limit" as "the

Fig.7.

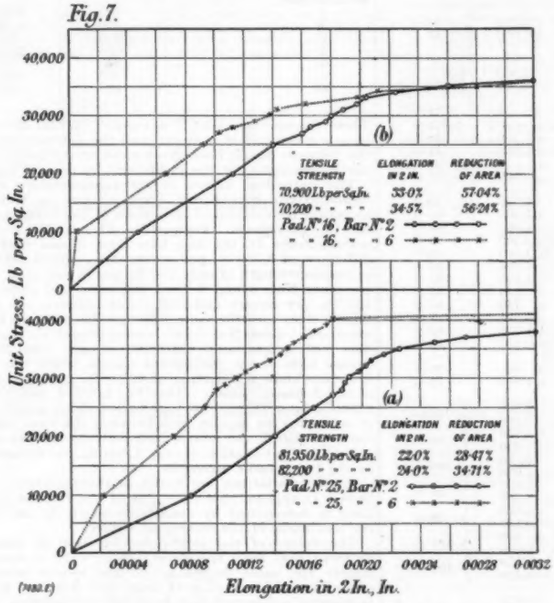

Unit Stress, Lb per Sq. In.
Elongation in 2 In., In.
(b)
TENSILE STRENGTH
ELONGATION IN 2 IN.
REDUCTION OF AREA
70,900 Lb per Sq. In. 33·0% 57·04%
70,200 " " " 34·5% 56·24%
Pad N° 16, Bar N° 2
" " 16, " " 6
(a)
81,950 Lb per Sq. In. 22·0% 28·47%
82,200 " " " 24·0% 34·71%
Pad N° 25, Bar N° 2
" " 25, " " 6

FIG. 7. PRECISION TESTS. STRESS-STRAIN CURVES FROM TESTS OF MANUFACTURER D.

(*a*) HEAT NO. E–1192, PAD NO. 25, BARS NOS. 2 AND 6.
(*b*) HEAT NO. 8707–4, PAD NO. 16, BARS NOS. 2 AND 6.

The irregular form of these curves is typical of the stress-strain curves from annealed steel castings. It is only in exceptional cases, as shown in Fig. 6, that constant proportionality between stress and strain is found.

Fig.8.

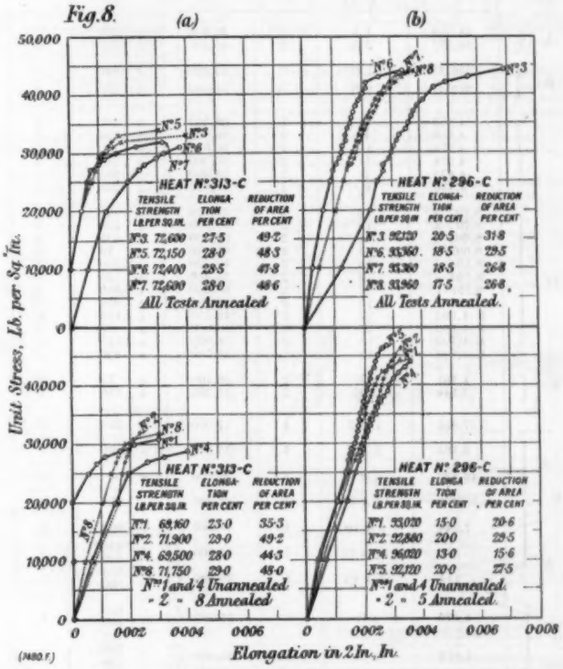


FIG. 8. PRECISION TESTS. STRESS-STRAIN CURVES FROM TESTS OF MANUFACTURER B.

(*a*) HEAT NO. 313–C. (*b*) HEAT NO. 296–C.

Showing the irregular curves typical of annealed steel castings, similar to those in Fig. 7.

The coupons were to be numbered from 1 to 10 from one end of the pad to the other and were to be tested as follows :—

No. 1 ...	...	Remove from pad unannealed.
No. 2 ...	...	Test for plotting stress-strain curve.
No 3 ...	...	Pull regular tension test.
No. 4 ...	...	Reserve.
No. 5 ...	...	Reserve.
No. 6 ...	...	Test for plotting stress-strain curve.
No. 7 ...	...	Pull regular tension test.
No. 8 ...	...	Reserve.
No. 9 ...	...	Reserve.
No. 10...	...	Remove from pad unannealed.

Standard A.S.T.M. 2-in. tension test specimens were to be used for all tests. The method suggested for obtaining the stress-strain curve was as follows :—

Apply Berry strain gauge.
Apply load of 2,000 lb. (10,000 lb. per square inch). Read gauge.
Apply load of 4,000 lb. (20,000 lb. per square inch). Read gauge.
Apply load of 5,000 lb. (25,000 lb. per square inch). Read gauge.
Apply load of 5,400 lb. (27,000 lb. per square inch). Read gauge.
Apply load of 5,600 lb. (28,000 lb. per square inch). Read gauge.

Continue to increase the load by increments of 200 lb. noting the gauge reading after the application of each increment of load, until the yield-point as marked by the strain gauge is reached. Remove strain gauge and pull the specimen as in a regular tension test, noting the

The suggestion that two bars be pulled in the regular manner to determine yield-point only was not followed.

Manufacturer C furnished six pads representing three acid open-hearth heats. The test programme was followed.

Manufacturer D furnished 12 pads representing four basic and three electric heats. The test programme was followed.

Manufacturer E furnished two pads, one from each of two acid heats. The test programme was followed.

Manufacturer F.—The pads furnished were not arranged exactly in accordance with the programme. Two pads were made from each heat, each pad providing four test bars. For each heat four bars from one pad were pulled in the regular manner determining the yield-point, while the other four bars were used to give stress-strain curves. Seven heats are represented, four acid and three basic. The method of obtaining the stress-strain curves was to place the bar in the testing machine and apply a load of 500 lb. Two Berry strain gauges were clamped on opposite sides of the bar and set at zero. Loads of 2,000, lb., 4,000 lb. and 5,000 lb. were placed on bar and readings obtained on both strain gauges after each load. The load was then reduced to 500 lb. and strain gauges removed and placed on opposite sides of the bar in a plane at right angles to the first plane of setting. Loads of 2,000 lb., 4,000 lb., 5,000 lb. and 5,400 lb. and increments of 200 lb. thereafter were placed on the bar until the strain gauges showed approximately 40 divisions or more. This method of taking reading on four sides of the bar was followed in order to determine if the bar was actually loaded axially.

Manufacturer G furnished one pad from each of two acid heats. The carbon content was respectively 0·27 per cent. and 0·48 per cent. As both pads were annealed at the same temperature, the grain condition in the higher

greatest load per unit of original cross-section which does not produce a permanent set." In the current testing of steel castings for railroad service, however, this stress is practically never measured or considered. In such work "elastic limit" means either the so-called elastic limit determined by the Johnson "50 per cent. method" or the so-called elastic limit determined by the method of Committee A–1 on Steel.* It should be noted that the determination of either of these limits depends on a change in the proportionality between stretch and load. Consequently by the definitions of this society they are species of "proportional" and not "elastic" limit.

For either of the two "elastic limits" to have a real physical meaning in connection with the steel the stress-strain curve must start as a straight line, showing constant proportionality between load and elongation, and then bend more or less sharply towards a horizontal position. This type of curve is illustrated by Fig. 6 showing the two curves from bars Nos. 2 and 6, pad No. 22, heat No. E–1,192, manufacturer D. These show an almost perfect initial straight line with a break of "elastic limit" at about 38,000 lb. per square inch. This type of curve is not usual for steel castings, which are better represented by Fig. 7, the curves from pad No. 25, heat No. E–1,192, and from pad No. 16, heat No. 8,707–4, also from manufacturer D. In these curves there is no straight-line portion. The ratio of elongation to load increases continuously from the origin. By any rigid definition the material has zero elastic limit. The same indication is shown in practically all of the curves plotted. Curves from four bars from heats Nos. 313–C and 296–C by manufacturer B are shown in Fig. 8 as further examples. These are drawn with the elongation on a smaller scale than was used in Figs. 6 and 7, and this

*Loc. cit.

causes the initial part of the curve to appear more nearly a straight line. If the elongation scale is still further reduced, it becomes possible to draw a straight line which will appear to represent the points fairly closely, and by so doing an apparent elastic limit can be obtained. This procedure, however, is merely measuring the elongation by a precise extensometer and then plotting so as to eliminate the effect of this precision of measurement. To secure accurate information regarding the properties of the steel, it is necessary to measure elongation and load with precision and to plot them to a scale corresponding to the precision of measurement.

The curves plotted from the whole body of tests lead to the belief that a tension specimen of cast steel stretches irregularly under a gradually increased load. The irregularity is partly due to bending of the specimen, but is also largely due to the nature of the material. This conclusion is based on the experiments made by manufacturer F with two and four strain gauges and on experiments, not reported here, made by manufacturer D with three strain gauges.

The curves reproduced show that the general rule is for the stretch to increase at a slightly greater rate than the load until the yield range is reached. There is then a rapid increase in stretch with a very slight increase in load. It is important to note that there is no definite point of inflection marking the change from the so-called elastic range to the yield range. In other words, the stress-strain curves do not show any definite stress, before the yield range is reached, at which a physical change affecting the strength of the material takes place. Precise measurement and plotting of the stress-strain curve fails to determine a "true elastic limit" for cast steel.

The yield range marks a change in the strength of the material, and as such requires critical attention. In the light of the information given by the curves, the Johnson 50 per cent. elastic limit method is seen to be an arbitrary method of determining a point near the beginning of the yield range. The yield-point as determined by the drop of beam marks a point at which the yield is well developed. In round figures the total stretch in the 2-in. specimen is between 0·001 in. and 0·002 in. for the Johnson limit and between 0·01 in. and 0·02 in. for the drop of beam. This applies to the cast steel specimens, and, other things being equal, the stretch for either of the points in question will be greater in proportion to the tensile strength.

Information as to the relative positions of the Johnson point and the drop-of-beam yield-point are given in Table II. This shows for each pad the average value of the stress at the Johnson point and at the drop of beam, together with the number of bars covered by these averages, and the deviation of the maximum and minimum values from the average values.

It will be seen that in the tests furnished by manufacturer F the value of the Johnson elastic limit is abnormally high in relation to the yield-point, in some cases being actually higher than the yield-point. The reason for this anomaly is not clear. It is possible that it can be explained by the fact that the bars for the stress-strain curves were loaded to 25,000 lb. per square inch, then released and after the position of the strain gauge was changed, the bars were reloaded and the test completed. The elastic limit may have been increased by the preliminary loading. Leaving these tests out of consideration, the value of the Johnson elastic limit averages 84·5 per cent. of the yield-point stress. The running tests showed that the average value of the elastic limit found by the method of Committee A–1 is approximately 89 per cent. of the yield-point stress, so that in round figures the Johnson limit is 95 per cent. of the A–1 limit.

The table shows that in a set of tests for a given heat the values found for the Johnson limit show a greater deviation from the average value than is the case with the values found for the yield-point. To put this in concrete form, average values for the deviation for the tests of each manufacturer have been computed and are as follows :—

Average Deviation of Maximum and Minimum Values from the Average Value.

—	Yield-Point by Drop of Beam, Lb. per Sq. In.	Johnson Elastic Limit, Lb. per Sq. In.
Manufacturer.		
A	625	1,625
B	590	1,560
C	596	333
D	935	2,156
E	162	750
F	500	3,364
G	800	1,550

These figures show that if a number of bars are taken from a given pad of uniform steel the determination of the Johnson elastic limit gives more erratic results than the determination of the yield-point by drop of beam.

The individual values of the representative curves reproduced in Figs. 6 and 7 are collected in Table III to permit comparison of the values of the Johnson limit and the yield-point. For pad No. 25, heat No. E–1,192, manufacturer D, the two bars Nos. 2 and 6 show a difference of 6,750 lb. per square inch, with a difference in tensile strength of only 250 lb. per square inch. The two bars Nos. 3 and 7 from the same pad show only 150 lb. per square inch difference between the yield-point values with the same difference between the tensile strengths. Heat No. 7,244, manufacturer F, has four bars with a maximum difference of only 1,000 lb. per square inch in the yield-point values, while the other four bars show a variation of 8,700 lb. per square inch in the Johnson values. Heat No. 8,707–4, pad No. 16, manufacturer D, on four bars tested shows a difference of 4,500 lb. per square inch between the two Johnson values, 1,450 lb. per square inch between the two yield-points, and a variation of only 1,000 lb. per square inch in the four tensile strengths.

Similar variations are found in the majority of the tests. It appears that the value of the Johnson elastic limit is determined by conditions which do not affect the usefulness of the casting in service.

The values of the yield-point by drop of beam in different bars from the same casting vary in approximately the same degree as do the tensile strength, elongation and reduction of area, and therefore appear to stand in a closer relation to the service strength of the steel than is the case with the values found for the Johnson limit.

Table II.—Relation of Yield-Point to Elastic Limit by Johnson Method.

Manufacturer.	Heat No.	Pad No.	Yield-Point by Drop of Beam. No. of Bars.	Yield-Point by Drop of Beam. Average Value, Lb. per Sq. In.	Yield-Point by Drop of Beam. Deviation of Maximum and Minimum Values from Average, Lb. per Sq. In.	Elastic Limit by Johnson Method. No. of Bars.	Elastic Limit by Johnson Method. Average Value, Lb. per Sq. In.	Elastic Limit by Johnson Method. Deviation of Maximum and Minimum Values from Average, Lb. per Sq. In.	Elastic Limit as per Cent. of Yield-Point, per Cent.
A	34,559	1 A	2	45,500	± 500	2	29,250	± 2,250	64·5
	34,577	2 A	2	45,250	± 750	2	37,000	± 1,000	81·5
B	296 C	1 B	2	47,700	± 650	4	43,000	± 980	90·5
	313 C	2 B	2	36,000	± 525	4	31,300	+2,350 / −1,350	87·0
C	4,558	A	2	38,100	± 2,500	2	27,000	± 0	71·0
	4,558	B	2	36,600	± 125	2	27,000	± 0	74·0
	4,574	C	2	36,650	± 50	2	25,500	± 500	69·5
	4,574	D	2	36,700	± 325	2	26,000	± 1,000	71·0
	4,436	E	2	36,300	± 300	2	25,000	± 0	69·0
	4,436	F	2	36,600	± 275	2	27,500	± 500	75·0
D	8,707–4	16	2	38,725	± 725	2	30,500	± 2,750	79·0
	8,707–4	12	2	37,200	± 250	2	33,000	± 1,000	89·0
	8,695–4	8	2	34,500	± 1,875	2	28,500	± 2,000	83·0
	8,695–4	4	2	35,300	± 75	2	33,500	± 3,500	95·0
	8,154–3	13	2	40,300	± 2,250	2	31,500	± 4,500	78·0
	8,154–3	14	2	35,400	± 125	2	32,600	± 1,625	92·0
	9,159–1	17	2	38,300	± 2,300	2	34,100	± 1,125	89·0
	9,159–1	15	2	38,200	± 1,925	2	31,250	± 250	81·5
	E–1,192	22	2	42,550	± 1,185	2	38,750	± 750	91·0
	E–1,192	25	2	45,000	± 75	2	36,625	± 3,375	91·5
	E–1,193	18	2	38,900	± 2,125	2	36,000	± 1,750	92·5
	E–1,194	19	2	44,550	± 450	2	37,250	± 3,250	83·5
E	1,161	1 E	2	36,400	± 75	2	27,500	± 500	75·5
	1,144	2 E	2	37,300	± 250	2	26,000	± 1,000	70·0
F	37,825	1 & 2	4	37,300	± 500	4	35,000	+4,300 / −5,400	89·0
	9,424	3 & 4	4	35,500	± 1,000	4	29,450	+1,150 / −1,050	83·0
	49,892	5 & 6	4	35,700	± 1,000	4	38,450	+5,150 / −11,050	108·0
	670	7 & 8	4	36,000	± 750	4	32,100	+5,600 / −4,700	89·0
	7,244	9 & 10	4	37,500	± 500	4	35,950	+5,050 / −5,150	96·0
	836	11 & 12	4	35,300	+ 450 / − 300	4	35,800	+975 / −1,025	101·0
	114	13 & 14	4	38,900	+ 325 / − 700	4	39,650	+3,050 / −3,850	102·0
G	4,479	1 G	4	46,200	+ 650 / −1,400	4	40,225	+2,275 / −2,925	87·0
	4,492	2 G	4	35,000	+ 700 / − 450	4	31,600	+ 350 / − 650	90·0

Average (excluding manufacturer F), 84·5 per cent.

Table III.—Comparison of Values of Johnson Elastic Limit and Yield-Point.

Manufacturer.	Heat No.	Pad No.	Bar No.	Johnson Elastic Limit, Lb. per Sq. In.	Yield-Point, Lb. per Sq. In.	Tensile Strength, Lb. per Sq. In.	Elongation in 2 In., per Cent.	Reduction of Area, per Cent.	Fig. No.
D	E–1,192	22	2	38,000	—	81,650	23·5	31·2	6
		22	6	39,500	—	82,000	22·5	28·5	6
		22	3	—	44,400	81,450	18·0	34·4	—
		22	7	—	40,700	82,050	22·5	31·8	—
		25	2	38,250	—	81,950	22·0	28·5	7
		25	6	40,000	—	82,200	24·0	34·7	7
		25	3	—	39,900	82,000	23·5	33·1	—
		25	7	—	40,050	82,150	22·5	33·8	—
D	8,707–4	16	2	32,250	—	70,900	33·0	57·0	7
			6	27,750	—	70,200	34·5	56·2	7
			3	—	38,000	70,200	34·5	58·6	—
			7	—	71,200	71,200	32·5	56·0	—

High-Voltage Electric Power Transmission in California.—The Southern California Edison Company, having two single-circuit tower lines 241 miles long from its Big Creek hydro-electric plants to near Los Angeles, had the alternative of either duplicating these lines or of raising the voltage upon them. The latter procedure was found to be much the more economical. Other things being equal, the amount of power that can be transmitted varying with the square of the voltage, and the existing voltage being 150,000 volts, a doubling of capacity will result by raising the voltage to 220,000 volts. To avoid the difficulties inherent in changing over generating and sub-stations built for the lower voltage, and in which adequate clearances would be very difficult to obtain, it was decided to use auto-transformers at each such station, transforming between 150,000 volts and 220,000 volts. Additional sectionalising switching stations will be built in the line, making six in all, so that the rebuilding of the line may be done without crippling service, and insulator testing can be done at any convenient time. An extension of the line 30 miles in length will be built so that the completed 220-kv. system will be 270 miles long. Preparatory to the final design, a considerable amount of investigation and research was carried on. The best form of insulation that would fit existing towers had to be determined, standard suspension insulators being preferred over new untried designs. Laboratory high-voltage tests of insulation at oscillator frequencies of 30,000 and 50,000 cycles and at continuous 60 cycles were undertaken in order to get as much information as possible, all such tests being made in dummy towers so as to duplicate actual conditions as nearly as possible. The next step was to equip 27 miles of one Big Creek line with additional insulators and shield rings and carry out field tests. This section of line was energised to 280,000 volts for one month, and to 241,000 volts for about five months, extending through the greater part of the rainy season. Considerable care was taken to obtain reliable measurements of voltage, current and corona losses. The results of the laboratory and field tests lead to the firm belief that nothing extraordinary will happen with transmission at 220,000 volts, which has been adopted.

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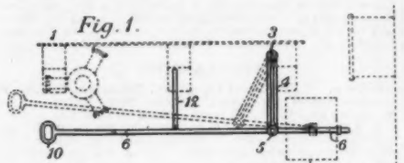
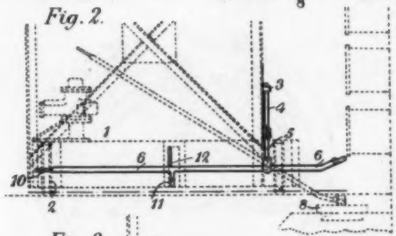
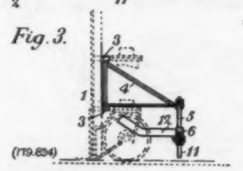
GAS ENGINES, PRODUCERS, HOLDERS, &c.

179,834. South Metropolitan Gas Company, London, and H. G. H. Kinner, Deptford, London. Lifting Producer Doors. (3 *Figs.*) May 27, 1921.—This invention relates to a device for lifting the cast-iron producer doors in retort houses. 1 is a hydraulic pusher mounted on wheels. The pusher 1 is provided with trunnion bearings 3 in which a bracket 4 is mounted. The bracket 4 carries a rod 5, the lower end of which is forked to receive a lifting arm 6. 8 is a producer door having thereon a lug provided with a hole into which the forward end of the arm 6 can be inserted. The outer end of the arm is provided with a handle 10; the arm 6 is also provided with a stop 11. 12 is



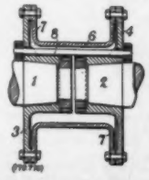




an arm fixed to the pusher 1 and forms a catch for the arm 6. In operation, the pusher 1 is moved opposite the producer door 8, the inner end of the arm 6 is lowered into the position shown in dotted lines in Fig. 2, and the end is pushed forward into the hole in the lug. The arm 6 is then pulled downwards by the handle 10 from the dotted position in Fig. 2 and is drawn backwards and sideways under the catch 12 to the position shown in dotted lines in Fig. 1, in which position it is held while the pusher 1 is moved away from the producer. After the producer has been charged with coke, the pusher 1 is brought back and the door 8 is lowered back into position by a reversal of the operations just described. (*Sealed.*)

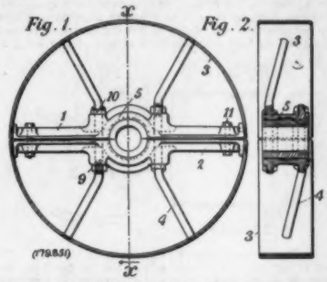
MACHINE AND OTHER TOOLS, SHAFTING, &c.

179,770. K. Baumann, Barnfield, Urmston, and Metropolitan-Vickers Electrical Company, Limited, Westminster. Flexible Couplings. (3 *Figs.*) March 24, 1921.—The shaft coupling, according to the present invention, possesses eccentric flexibility but longitudinal rigidity, and comprises a torsionally rigid member which permits eccentric flexibility of the shafts and a longitudinal rigid member which also permits eccentricity of the shafts. 1, 2 are the shafts to be coupled together, 3, 4 are rigid flange members secured to the ends of the shafts, and 6 is a coupling member comprising a cylinder formed with flanges 7 at each end, the flanges being connected at their



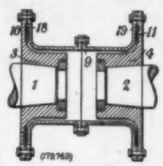
outer peripheries to the outer peripheries of the members 3, 4, and constituting the resilient or flexible diaphragm elements of the coupling. To enable a flexible coupling as described to transmit thrust, the rigid members 3, 4 are connected by a bolt 8. The bolt 8 is arranged as near to the axis of the shafts 1, 2 as possible. The torque is transmitted from one shaft to the other through the resilient diaphragm elements and the tubular portions and not through the bolt, whilst the thrust is transmitted through the bolt almost entirely, the latter being sufficiently flexible transversely to conform to the relative movements between the shafts permitted by the diaphragm elements. (*Sealed.*)

179,851. W. J. Manning, Wolverhampton. Split Pulleys. (5 *Figs.*) June 28, 1921.—According to this invention, the spokes are detachably connected to the boss and are adapted to act also as bolts for securing the two halves of the boss together. The pulley is formed in two halves 1, 2. Each pulley half comprises a rim 3, spokes 4 and a half-boss 5. The half-bosses have extensions which pass to the ends of the half-rim 3 to which they are riveted. The spokes 4 are riveted to the rims 3 and detachably connected to the half-bosses 5 in such a manner that



the spokes form clamping bolts for holding the two pulley halves together. Two spokes are riveted centrally to each half-rim and are cranked outwards in opposite directions to pass through perforations in the half-bosses on each side of the central plane of the pulley. The ends of the spokes are screw-threaded for receiving the clamping nuts 9, whilst collars 10 are formed on the spokes to take the clamping pressure when the nuts are tightened. The ends of the extensions are clamped together by the bolts 11. (*Accepted May 24, 1922.*)

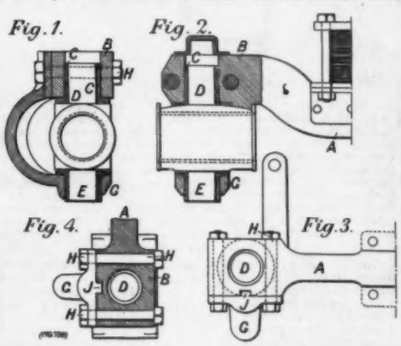
179,769. K. Baumann, Barnfield, Urmston, and Metropolitan-Vickers Electrical Company, Limited, Westminster. Flexible Couplings. (6 *Figs.*) March 24, 1921.—The invention relates to couplings of the class which comprise two resilient diaphragms respectively secured by their outer edges or rims to the shafts to be coupled and united by a tubular distance-piece which is relatively long. According to this



invention, the resilient diaphragms take the form of end flanges made integral with a tubular distance piece. The tubular metal distance piece 9 is made in two halves formed integrally with flange portions 18, 19, respectively, which constitute the resilient members of the coupling and are connected by their outer peripheries to the flanges 10, 11, of the coupling members 3, 4, which are secured to the shafts 1, 2, by means of nuts. (*Sealed.*)

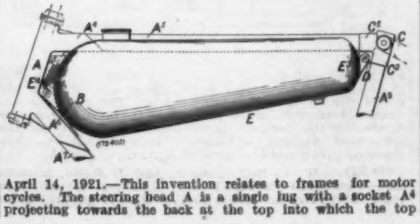
MOTOR ROAD VEHICLES.

179,739. S. E. Alley, Westminster. Steering Axle-Ends. (4 *Figs.*) March 12, 1921.—According to the invention, the axle A has at each end an enlarged part B to receive the bearing C for one of the stub-axle trunnions D. The other stub-axle trunnion E is supported in a bracket G which, according to the invention, is secured to one of the side faces of the axle-end B



by bolts H passing one on either side of the bearing, which, with or without the addition of a key or feather J between the surfaces, serve also as locating means. The bracket G is bowed to clear the steering and tie-rod arms and extends either forward or to the back substantially at right angles to the axle A, and carries at its outer end a bearing to receive the second stub-axle trunnion. (*Sealed.*)

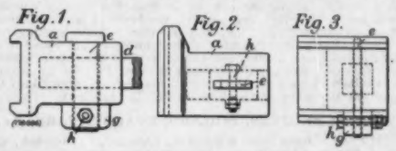
179,405. The Villiers Engineering Company, Limited, Biakenhall, Wolverhampton, F. H. Farrer, Penn, and F. Pountney, Penn. Motor Cycle Frames. (2 *Figs.*)



April 14, 1921.—This invention relates to frames for motor cycles. The steering head A is a single lug with a socket A^4 projecting towards the back at the top into which the top tube A^5 is fitted, and a similar but sloping socket A^6 at the bottom into which the front down tube A^7 is fitted. These two socket portions are connected together by a wide web B, which constitutes an attachment web. At the back of the top tube A^5 is the rear upper junction lug C having a socket C^2 for the reception of the top tube, and a socket C^3 for the seat pillar tube A^8. Bridging the two socket portions C^2, C^3 is a web D, which constitutes the rear attachment rib. The tank E is provided at the top with a channel in which lies the top tube A^5, and each end of the tank is provided with a projecting flange, of which the rear one E^3 is attached to the web D on the rear junction lug and the front one E^4 is attached, preferably at two points, to the web B on the steering head lug. (*Sealed.*)

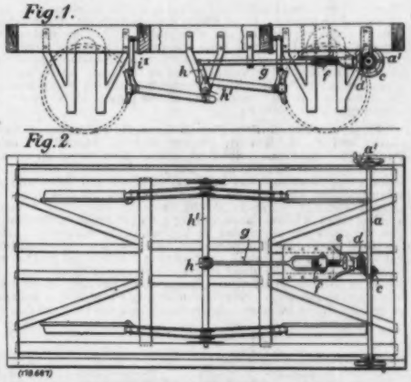
RAILWAYS AND TRAMWAYS.

179,686. W. E. Sevier, Ebbw Vale, Wales. Buffers. (3 *Figs.*) February 17, 1921.—This invention relates to buffers of the type wherein shoes *a* carrying the buffer springs fit over the ends of the buffer shanks *d* and are secured thereon by keys *e* passed through vertical slots in the shoes *a* and the buffer shanks *d*, which keys in turn are locked in place by pins or bolts passed transversely through the lower ends thereof. According to this invention, an extension *g* is made on the bottom of the



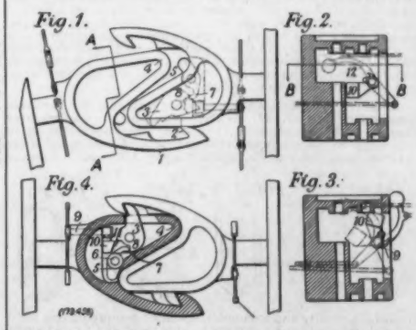
buffer shoe *a* through which the vertical slot for receiving the key *e* is continued, and the length of the key *e* is such that its lower end enters the slotted extension, both the key and extension being drilled transversely to receive a bolt *h* for securing the key in position. The bolt is provided with lock nuts, and owing to the proximity of the extension *g* on the shoe to the sole bar of the wagon, the nuts cannot be removed to release the key without the use of a suitable spanner. (*Sealed.*)

179,687. W. E. Sevier, Ebbw Vale, Wales. Hand Brakes. (4 *Figs.*) February 17, 1921.—This invention relates to brake mechanism of the kind capable of being operated from either side of the vehicle, and comprising an operating shaft *a* extending across the vehicle and mounted to rotate in brackets bolted to the sole bars, and means for transmitting motion from the shaft *a* to the brake shaft A^1, by either screw and mitre bevel gear or screw gear and a crank lever. In one form of the invention, the operating shaft *a*, which has a hand wheel a^1 at each end for



imparting rotation from either side of the vehicle, has a mitre bevel wheel *c* keyed thereon near the middle of its length. This bevel wheel *c* gears with a similar bevel wheel *d*, on a screw-threaded rod *e*, mounted to rotate in a bearing bracket bolted to the underside of the vehicle framing, but prevented from moving endwise in this bearing. The screw-threaded rod *e* is disposed longitudinally of the vehicle and actuates a trunnion nut *f* connected by a forked connecting rod *g* with a lever arm A on the brake shaft A^1. The brake shaft is connected with the brake shoes by lever arms and rods in the usual manner, the shoes being suspended by links *i* from brackets attached to the bottom framing of the vehicle. (*Sealed.*)

179,456. T. F. Redington, London. Automatic Mechanical Couplers. (4 *Figs.*) June 16, 1921.—This invention relates to mechanical couplings for railway vehicles. The improved coupling comprises complementary couplers 1, each provided with a hook face 2, which can engage with a

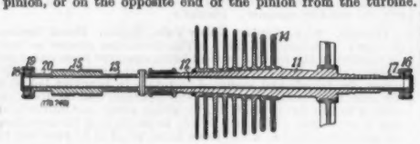


catch 3, dependent for its operation on the engagement of the coupler head 4 with a tumbler 5, which is pivoted on the coupler. The tumbler is connected with the catch 3 by a wiper arm 7, on the tumbler, which comes in contact with face 8 on the catch 3. Mounted eccentrically on a releasing spindle 9 worked by hand

fitted to each coupler, with provision for taking up lost movement, is a wedge-shaped locking member 10, which engages with a corresponding wedge face 11, on the adjacent catch 3 so as to lock the hook in the engaged position. The locking member 10 is capable of movement in three stages, first laterally, by reason of its eccentric mounting on the spindle 9 so as to disengage the wedge face 11, then circularly, conjointly with the spindle, so as to clear the catch 3 and abut by gravity against the upper side thereof, the second position corresponding to the "set to couple" position shown in dotted lines in Fig. 3, and thirdly, circularly into the "not to couple" position shown in full lines in Fig. 3, in which the locking member and associated parts are clear of the catch 3, and are so disposed in relation to the release spindle 9, that they are held by gravity in the "not to couple" position. In operation to effect the withdrawal or release of the locking member 10 when the couplers are in a condition of tension, the release spindle 9 is rotated. By this the locking member 10 is displaced laterally so as to bring the wedge surface thereon out of contact with the face 11, and to permit the locking member to be rotated with the shaft, when a tappet engages a follower on the boss of the locking member 10. Continued rotation of the spindle 9 is accompanied by angular movement of the locking member 10, into the "set to couple" position, and on the execution of the releasing movement of the spindle, the locking member 10 occupies the "not to couple" position. To effect engagement, the lever 12 is placed in the "set to couple" position, and on two vehicles coming into contact, the projecting ends of the tumblers 5 are forced home by the extremity of the head 4. As soon as the catch 3 clears the locking member, the locking member 10 falls by gravity to the locked position, the lever 12 moving by gravity into the position shown in dotted lines in Fig. 2. (*Sealed.*)

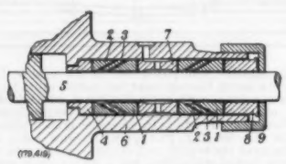
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

179,749. John Brown and Co., Limited, Clydebank, and S. J. Pigott, Clydebank. Transmission Gearing. (2 *Figs.*) March 17, 1921.—This invention relates to transmission gearing for use with turbines in which two couplings are provided for connecting the turbine rotor and the pinion. The couplings are spaced axially apart, one being more remote from the turbine than from the pinion. In gearing, according to the invention, the second coupling is located on the opposite end of the turbine from the pinion, or on the opposite end of the pinion from the turbine.



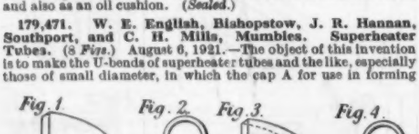
The rotor spindle 11 is tubular and is freely mounted on a divided shaft, the sections 12, 13 of which are rigidly connected together between the turbine 14 and the pinion 15. The end of the tubular spindle 11 remote from the pinion 15 carries a coupling member 16 engaged by a co-operative coupling member 17 at that end of the shaft. The opposite end of the shaft carries another coupling member 18 engaged by a co-operative coupling member 19 at the end of the trunnion 20 of the pinion 15 remote from the turbine 14. (*Sealed.*)

179,419, R. H. Smith, Forest Gate, H. Y. Mosey, Forest Gate, and F. S. Smith, Forest Gate. Metallic Gland Packings. (2 *Figs.*) April 26, 1921.—This invention relates to packing for stuffing-boxes of the type comprising alternately arranged rings of soft and hard metal of angular form and so arranged that longitudinal pressure on them causes them to expand radially. The improved packing comprises a male packing ring 1, a female packing ring 2, and a spreading element 3. The elements are assembled in the following manner: After the usual gland ring 4 is passed on to the piston rod 5 and into the stuffing-box 6, a female packing ring 2 is inserted so that its base abuts against the gland ring 4. The spreading element 3 is placed in position so that its exterior abuts against the internal face of the female ring. Next the male ring 1 is placed in position so that its coned exterior face abuts against the internal face of



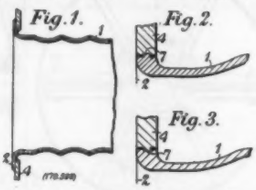
the spreading element 3. The three elements thus arranged are placed in position by the pressure of the hand only. A lantern bushing 7 is next inserted and a further packing unit composed of similar pieces 1, 2 and 3 is then placed in position and the gland 8 is placed against the outer or flat end of the male packing ring 1, after which the gland nut 9 is tightened up in the usual manner. When the gland nut 9 is tightened, the pressure is taken up by the gland 8 and resisted by the gland ring 4 at the inner end of the box, the effect being to cause the elements 1, 2 and 3 of each packing unit to enter into closer engagement with each other with the result that the female packing rings 2 are caused to expand outwardly against the walls of the stuffing-box 6, and the male packing rings 1 are caused to press inwardly against the rod 5. The central apertures in the spreading elements 3 are somewhat larger than the diameter of the rod 5, thereby producing an annular space around the rod which serves as a reservoir for oil and also as an oil cushion. (*Sealed.*)

179,471. W. E. English, Bishopstow, J. R. Hannan, Southport, and C. H. Mills, Mumbles. Superheater Tubes. (8 *Figs.*) August 6, 1921.—The object of this invention is to make the U-bends of superheater tubes and the like, especially those of small diameter, in which the cap A for use in forming



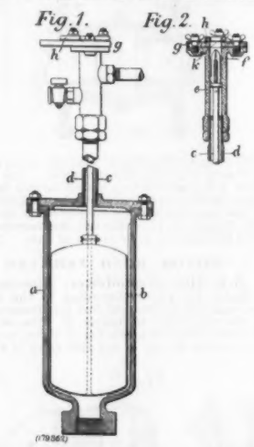
the bend is readily and economically made by stamping one piece of metal and producing a cap whose edge presents a figure having parallel sides joined by rounded portions of the same radius as the diameter of the tubes to be connected by the U-bend and of a length equal to the diameters of the two tubes plus the space which is required between them. According to this invention, a bridge-piece B is then taken of such shape that it will, when placed in recesses a^2 formed in the parallel sides of the edges of the cap, leave two openings corresponding, in diameter and relative position, with the ends of the two tubes. After the bridge-piece has been welded in place, the cap is ready to be welded in place on the two tubes. (*Sealed.*)

179,598. W. S. Thompson, Dundee. Securing Boiler Furnace Tubes. (8 *Figs.*) February 1, 1921.—This invention relates to an improved method of securing furnace tubes of marine boilers in position. This invention consists broadly in forming the furnace tubes 1 of a boiler with flanges 2, which lie wholly outside the end plates 4, for the purpose of causing the furnace tube to take the outward strain of the back and front



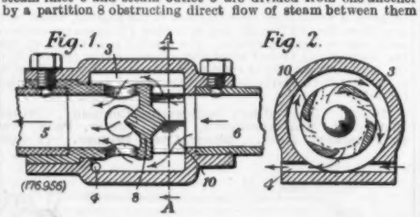
plates, and securing the tubes in position by welding. In another manner of carrying out the invention, the flanges 2 on the furnace tube may be fitted into a recess or groove cut in the edge of the hole in the end plates 4, or a raised step 7 (Fig. 3) may be formed around the inner edge of the hole and fitted into a groove in the tube flange or the raised step may be on the tube flange and the groove in the inner edge of the hole in the end plate (Fig. 2). The joints are afterwards welded. (*Sealed.*)

179,862. The Vulcan Boiler and General Insurance Company, Limited, Manchester, and F. H. Bullock, Manchester. Vacuum Breakers. (6 *Figs.*) July 26, 1921.—This invention relates to vacuum breakers employed in connection with steam engine condensers to prevent flooding of the engine cylinder by an undue rise of water in the condenser. The invention comprises the arrangement, in connection with a condenser or vacuum chamber, of an air inlet which is normally sealed by a diaphragm and a float carrying a spear head whereby an abnormal accumulation of water in the chamber is caused to pierce or break the seal. The vacuum breaker illustrated comprises a chamber *a* containing a float *b* having a stem *c* passing through a tube *d* to the interior of the air inlet fitting *e*. The



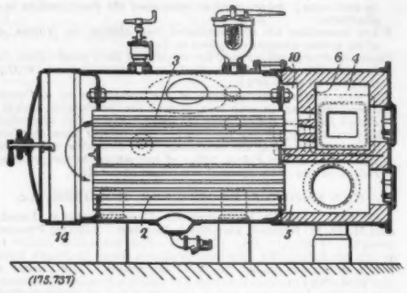
end of the stem *c* has attached thereto a spear head *f*. The top of the air inlet fitting *e* is provided with a cap *g* having therein a diaphragm *k* comprising a strip of vulcanised silk which is clamped over the central aperture of the cap *g* by a washer plate *h*. The lower end of the float chamber *a* is connected either directly to the condenser or to the steam exhaust or eduction pipe. In the event of an undue accumulation of water in the condenser, the water obtains access to the float chamber *a* and lifts the float *b*. By such elevation of the float, the spear head *f* pierces the diaphragm *k* so admitting air whereby the vacuum is destroyed and the water caused to fall. The steam cylinder is thereby saved from being flooded or waterlogged. (*Sealed.*)

176,956. A. E. Tompkins, Little Brookley, Brockenhurst. Steam Dryers. (5 *Figs.*) January 14, 1921.—This invention relates to steam dryers of the vortex type. A steam dryer having a water separating chamber 3 in which the steam is given high velocity rotary flow in order to separate out the contained water by centrifugal force is characterised by the fact that the steam inlet 6 and steam outlet 5 are divided from one another by a partition 8 obstructing direct flow of steam between them



and having guide-deflecting passages 10 therein, through which the whole of the inflowing steam passes, and by which high velocity rotary flow is imparted to it. The water discharge outlet 4 is tangential to the periphery of the separating chamber 3, whereby the discharge of the separated water takes place continuously through the tangential outlet 4 under the action of centrifugal force and independent of gravity. (*Sealed.*)

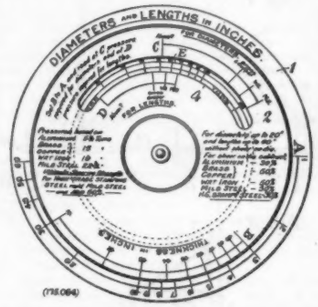
175,737. W. T. Bell, Lincoln, and J. Wells, Lincoln. Gas-Fired Multi-Tubular Boiler. (2 *Figs.*) November 18, 1920.—This invention relates to that class of gas-fired multi-tubular boilers in which the fire tubes are arranged in two horizontal nests or series, one above and one below the central horizontal line of the boiler and connected at the back end by a chamber, the combustion chamber being partly inside the boiler and connecting to the upper nest of pipes and the outlet chamber connecting to the lower nest of pipes. According to this invention, a gas-fired multi-tubular boiler has two nests of horizontally-arranged fire-tubes 2, 3, one above the other, a combustion



chamber 4 positioned outside the boiler at one end and having a perforated baffle 6 through which the ignited gases pass into another chamber 10 and then through the set of tubes 3, a chamber 14 at the other end into which the gases pass before they enter the set of tubes 2 and an outlet chamber 5, adjacent the combustion chamber 4 and outside the boiler, for receiving the products of combustion from the set of tubes 2. The inlet and outlet chambers and baffle are of reinforced concrete or firebrick or a combination of the same. (*Sealed.*)

MISCELLANEOUS.

175,064. E. W. Bliss Company, Brooklyn, U.S.A., and London, and W. J. Smith, London. Slide Rules. (2 *Figs.*) November 10, 1920.—This invention has for its object to provide a slide rule of the circular type applicable for use in the calculation of the force required to press or blank out, with or without shear on dies, articles of circular or non-circular form from sheet metal of various thicknesses and kinds. A slide rule, in accordance



with this invention, comprises a pair of circular discs 1, 2, one, 1, larger than the other, superimposed concentrically, rotatable relatively to one another, and each bearing logarithmic scales, the upper and smaller disc 2 having an arc-shaped slot 4 struck from the centre of the disc and bearing one of the logarithmic scales, being used in conjunction with one of the logarithmic scales on the lower and larger disc. (*Sealed.*)

175,771. G. L. Saunders, Eltham Park, and D. A. Saunders, Eltham. Inclinometers. (2 *Figs.*) November 26, 1920.—This invention relates to inclinometers of the kind comprising a suspended weight and means to indicate the position thereof and braking means, to prevent movement of the weight on sudden shocks, operated by relative movement of masses having different inertias. Within a case 1 is mounted a frame 2 having two outwardly projecting brackets 3. These brackets carry a hollow shaft 3a. Within the hollow shaft 3a is a spindle 5 from which is supported a pair of hangers 6, 6a carrying at their lower ends a large weight 7. A third hanger 8 supported on the hollow shaft 3a carries at its lower end a small weight 10 which swings in a groove in the weight 7. A spindle 12 capable of rotating, is carried by the weight 7 and one hanger 6. The spindle 12 carries a crank 13, and the crank-pin engages a slot in the hanger 8. The spindle 12 also carries a double pawl brake

15 which co-operates with a toothed braking member 17 of arc shape carried on the frame 2. The indicating means comprises a scaled disc 18 driven through gearing 19, and the operative connection between the weight 7 and the indicating means comprises a cam or slotted plate 20 carried on a crank 21 on a spindle 22, on which one of the gear wheels 19 is mounted. A pin 23 carried on the hanger 6a of the weight 7 engages with the cam or slotted plate 20. In use, as the instrument is tilted longitudinally due to variation in the gradient, the weight 7 remains vertical and thus causes a movement of the scale 18, which gives an indication of the gradient. Should the instrument be submitted to a sudden shock such, for example, as a sudden acceleration, the difference of the inertias of the weights 7 and 10 causes relative movement between them, by which the spindle 12 is rotated, and the pawl brake member 15 is caused to engage the toothed arc shaped member 17 and prevent movement of the weight 7. (*Accepted March 8, 1922.*)